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OPERATIVE SURGERY

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THE COURSE OF
OPERATIVE SURGERY

A HANDBOOK
FOR PRACTITIONERS AND STUDENTS

BY
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SECOND ENLARGED EDITION

WITH A FOREWORD BY PROF. DR. A. BIER

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FOREWORD

THE course of surgical operations has recently undergone many changes. Originally the teaching was confined to the ligation of vessels, typical operations on the limbs and a few facial and cranial resections. These operations used to play an important part in the practice of surgery, but with further progress they have given place to others more frequently performed and therefore more essential. The surgical course was thus in need of a thorough modernizing. Many of the newer text-books have already taken account of the requirements, but I think my friend and pupil, Professor Schmieden, has accomplished the work of modernizing in a peculiarly happy manner. Not neglecting the older and appproved methods of interference or those ligations that are of practical import, he has managed so to describe the main operations done on the subject that the graduate as well as the student may gain something which will last him through life and be profitable in practice. The illustrations of all the operations are excellent.

I wish the book the widest circulation.

PROF. DR. A. BIER.

BERLIN.

TRANSLATOR'S PREFACE

PROFESSOR SCHMIEDEN'S name requires no foreword in Britain, still less in America. He was kind enough to hand over the sheets of the Second Edition as they appeared, so that the necessary additions could be made to the first translation. This explains why the German second edition and the English translation thereof are issued almost simultaneously. Dr. Schmieden has inserted a number of points that have rendered the second edition more useful to British and American readers.

The surgical tree of knowledge had become too complex. The Berlin surgeon has accordingly pruned it of alternative methods and left only the stem that is common to all countries. He has summed up the essentials. He has refrained from crowding his canvas with details that can be mastered only in the operating theatre.

The Germans possess at least one great advantage, they have abundance of operative material; this reacts upon the number and quality of their illustrations; our English literature is starved through lack of material. The translator therefore set to work to make of this a living English book. The work should assist the student to bridge the gap that now exists between anatomy and surgery, by affording him a connected and scientific survey of modern operations.

The final translation was carried out in Berlin in the light of a very complete series of operations conducted under Professor Schmieden's personal direction (*Ferienkursus.* 1912). I desire to express my indebtedness to Professor T. H. Bryce for the necessary leave of absence.

Dr. S. V. Telfer, of the Anatomy Department, undertook a careful reading of the proofs; he advanced a number of valuable and helpful suggestions.

The B.N.A. nomenclature has been retained on the blocks; its advantages are fully discussed in the Preface to the latest edition of Cunningham's "Manual of Anatomy."

The translator believes that the book will become the student's handbook in every college where English is the medium of surgical instruction.

ARTHUR TURNBULL.

THE UNIVERSITY,
GLASGOW,
August, 1912.

AUTHOR'S PREFACE TO THE FIRST EDITION

MODERN surgery is at once a fine art and a rich science. He who will master it must take care not to regard it as a handicraft; for the mastery of it demands exact knowledge of the most varied subjects. Present-day surgery does not selfishly utilize the achievements of other lines of research, but furthers and enriches them in its turn.

Out of the wide range of surgical instruction only topographical anatomy and surgical technique will be considered in these pages, and the latter only as far as can be practised on the dead subject. The purpose of the book is to sum up and illustrate what I am wont to portray in the course of operative surgery. This course is intended for either students or doctors, so that the beginner as well as the graduate may find his requirements met. My great difficulty has been to confine my copious material within the limits of a handy volume.

I have made the book more concise by not discussing the priority of individual methods, and in this respect it cannot be used for purposes of reference. Indeed I have all along included the names of authors only when they rendered the matter more intelligible or when customarily employed to distinguish and denote individual methods. Simple methods have been everywhere preferred to complicated ones, and the practice of Professor Bier's clinic has been closely followed.

Operations on the subject will ever be of the utmost importance in the surgical curriculum. The advances of modern technique have forced us to practise the newer operations systematically and to overstep the limits of time-honoured usage. A complete account of the operation course in surgery must amount to a text-book of operative procedure on the living body.

The text is accompanied by three hundred and fifty-four illustrations. They have been drawn to my great satisfaction by the artist, Fräulein Margarete Wendland, from my designs of operations performed on both dead and living subjects, and occasionally on patients. The purely diagrammatic drawings are simply sketches, though some of the sections are based on anatomical atlases. The illustrations from photographs were prepared with great thoroughness by the clinical photographer, Fräulein Gisela Ramm, of the Lette-Verein (Berlin), and completed in the Lette-Verein photographic studio. Dr. A. Mallwitz has acted as model for many of the photographs and has thus enabled me to delineate the surgical incisions in their topographical relations on a musculature splendidly developed by athletic exercises. The instrument plates were placed freely at my disposal by Messrs. H. Windler, of Berlin.

I tender my best thanks to all these my helpers in this work.

PROF. DR. V. SCHMIEDEN.

BERLIN,
January, 1910.

EXTRACT FROM AUTHOR'S PREFACE TO THE SECOND EDITION

CONSIDERABLE alterations and additions were made in the chapter dealing with operations on the cerebellum, excision of the tongue, pharyngotomy, technique of abdominal incisions, while the chapter on the surgery of the stomach and intestines was entirely remodelled. The following sections are quite new: suture of bone, puncture of joints, Bellocq's tamponade, extraction of teeth, extirpation of the inguinal glands and extirpation of the cervical glands.

A few of the earlier illustrations have been replaced by better ones and a considerable number of fresh ones added.

BERLIN,
1912.

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OPERATIVE SURGERY

SECTION I

LIGATURE OF THE MAIN ARTERIES

Introduction.—Vessel Ligation in General

It is best to start operating on the subject with the search for the large arteries. The acquisition of this much-practised art is useful in two ways. In the first place such knowledge is essential in emergency hæmorrhage from one or other of the large arterial stems opened by injury or erosion; it also enables us to render any given area bloodless prior to operation (*e.g.* the preliminary ligation of the carotid or lingual). In the second place we must know, and know most exactly, the surgical relationships of the more important arteries, since they are constantly with us in all major operations. It is the only way to escape doing needless damage. The surgeon can only attain the requisite feeling of confidence by making the course and relations of the great blood-vessels and nerves his very own; it is in this sense that these vessels form the direct or indirect guides to the surgeon's knife.

Choose the necessary instruments for artery ligation before commencing to operate. They are as follows:—A surgical knife of medium size, a pair of sharp-toothed retractors for skin and subcutaneous tissue, a pair of large blunt retractors for the muscles, a toothed forceps and a pair of anatomical forceps (the latter for isolating the sheath by blunt dissection), a Deschamp's aneurism needle (with some ligatures), and a pair of Cooper's scissors (cp. Figs. 1–7, page 2).

Every operator on the subject should make a special point of wearing rubber gloves. The time is past when the student was advised to overcome his natural diffidence in approaching fresh or preserved bodies by courageously handling the foulest material. Nowadays we welcome this natural sentiment, for we know it is the first duty of the practitioner trained in surgery to save his hands from all infection. But apart from the danger involved, the æsthetics of our profession require even the beginner to preserve his hands from impurities as far as possible, just as he is obliged to conclude operations on the subject by washing them thoroughly, whether he has worn gloves or not.

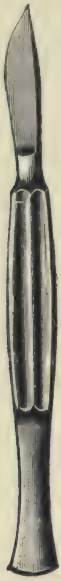

FIG. 1.—Surgical knife.

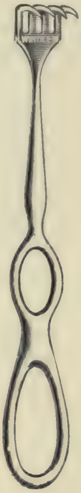

FIG. 2.—Sharp-toothed retractor.

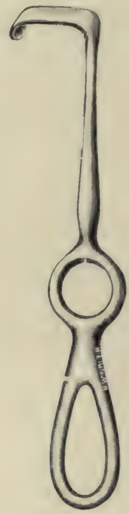

FIG. 3.—Blunt retractor.

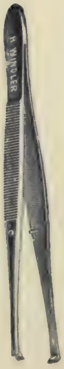

FIG. 4.—Surgical forceps.

FIG. 5.—Dissecting forceps.

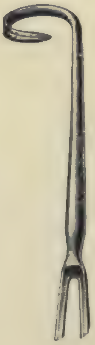

FIG. 6.—Aneurism needle (Deschamp's).

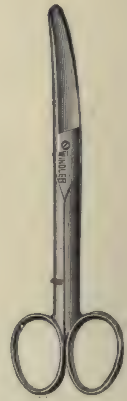

FIG. 7.—Scissors (Cooper's).

Let us now commence with the operation of vessel ligation. Start by carefully examining the part: feel the various bony projections, ligaments, muscle bellies and tendons that are involved. Then put the skin well upon the stretch with the left thumb and forefinger. Divide the skin with a sure hand, carrying the incision well into the subcutaneous fat, while at the same time the assistant pulls the edges of the wound apart with sharp retractors. The exposure of the vessel is the next step and will be described for each particular case.

In looking for arteries it is best to follow a definite plan, which one can rigidly adhere to and recall to mind just before incising. Neglect to do this often prevents the surgeon attaining his object, leads to the operation area being spoiled with useless cuts and finally renders any exact procedure impossible. This applies to operations on the subject as well as to those done on the living body.

As has been indicated, one should never begin to expose an artery without having an assistant to retract the soft parts. On reaching the position of the artery the operator divides the sheath, which often surrounds not only the artery but a bundle of arteries, veins and nerves: or better, he may isolate the artery from adventitious connective tissue with a pair of dissecting forceps. A ligature is then carried round the artery on a blunt aneurism needle (Deschamp's) and firmly tied. This ends the typical ligature, and nothing remains but to stitch the several layers of the wound. It is necessary for certain purposes to ligature at two points at least $\frac{3}{8}$ in. (1 cm.) apart and divide the vessel exactly between them with scissors.

A. The Iliac Artery and its Divisions.

1. *Common Iliac Artery and External Iliac.*

To expose the common iliac and its branches (external and internal iliacs) bear in mind the accompanying diagram (Fig. 8). The abdominal aorta divides about the level of the 4th lumbar into the two common iliacs. The vena cava divides at the same level and rests, like the artery, on the vertebral column. The common iliacs pass downwards and outwards at the inner edge of the psoas muscle. On the right side the vein lies external to artery, but on the left side the position is reversed. The common iliac divides at the upper margin of the sacro-iliac synchondrosis: the external iliac artery is its direct continuation, and proceeds along the pelvic brim till it passes under Poupart's ligament; at this point the deep epigastric artery is given off in a forward, inward and upward direction, this vessel being the most important one in the surgery of this region. The right external iliac artery assumes a different relation to its accompanying vein just beyond where the common iliac divides, for it crosses over and lies to its outer side.

We thus find both the external iliac arteries running to below Poupart's ligament on the outside of their respective veins. Passing into the groin as the femoral arteries they maintain this external position. In their entire course the vessels lie close against the peritoneum in loose connective tissue.

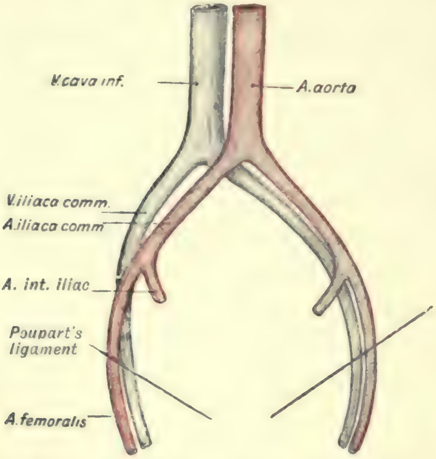

FIG. 8.—Diagram of common iliac artery and its branches.

The internal iliac artery runs straight downwards from where the common iliac divides; it then splits up into branches.

To expose the common iliac or internal iliac, the best way is to pursue the external iliac upwards. We describe the ligature of the latter artery first, as it is the easier.

External Iliac Artery.—Map out the course of the vessel on the abdominal wall, from the umbilicus to the mid-inguinal point. Make the incision parallel to the ligament and a finger's-breadth above it, starting near the anterior superior spine and continuing as far as the mid-inguinal point (*v.* Fig. 9*a*).[1]

On no account cut inwards beyond the mid-inguinal point, but adhere to the line as projected in the figure, with a view to preserving the deep epigastric artery and the cord intact. This incision divides skin, fat, and superficial fascia: the three layers of abdominal muscles are then divided in the whole extent of the skin incision, but only the tendinous part of the outermost muscle (external oblique) is encountered at this point. The fascia transversalis lies behind the transversalis muscle; divide it with care and do not

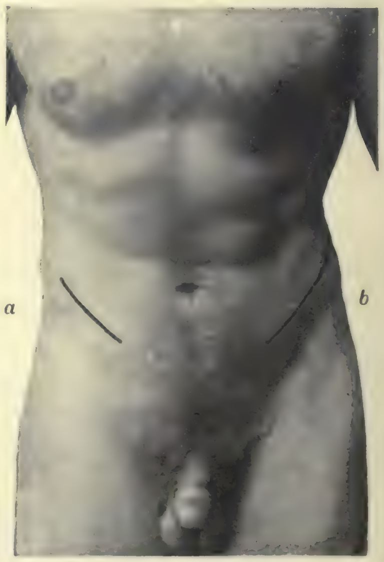

FIG. 9.—(*a*) Incision for the external iliac artery; (*b*) incision for the common iliac artery.

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[1] The mid-inguinal point is the centre of a line drawn from the anterior-superior spine to the symphysis pubis.—TR.

cut any deeper, for the loose extraperitoneal tissue is now reached and it is easy for a reckless operator to injure the peritoneum. After reaching this loose extraperitoneal tissue you press on into the depths of the wound, bluntly dissecting with the finger tips and displacing the shut peritoneal sac towards the umbilicus. The external iliac artery is soon met, with its vein on the inside. Ligature it by carefully passing the aneurism needle from within outwards, this being the best way to avoid injuring the neighbouring vein. The psoas muscle lies to the outer side of the artery. The origin of the deep epigastric artery comes into the line of incision, as shown in Fig. 10.

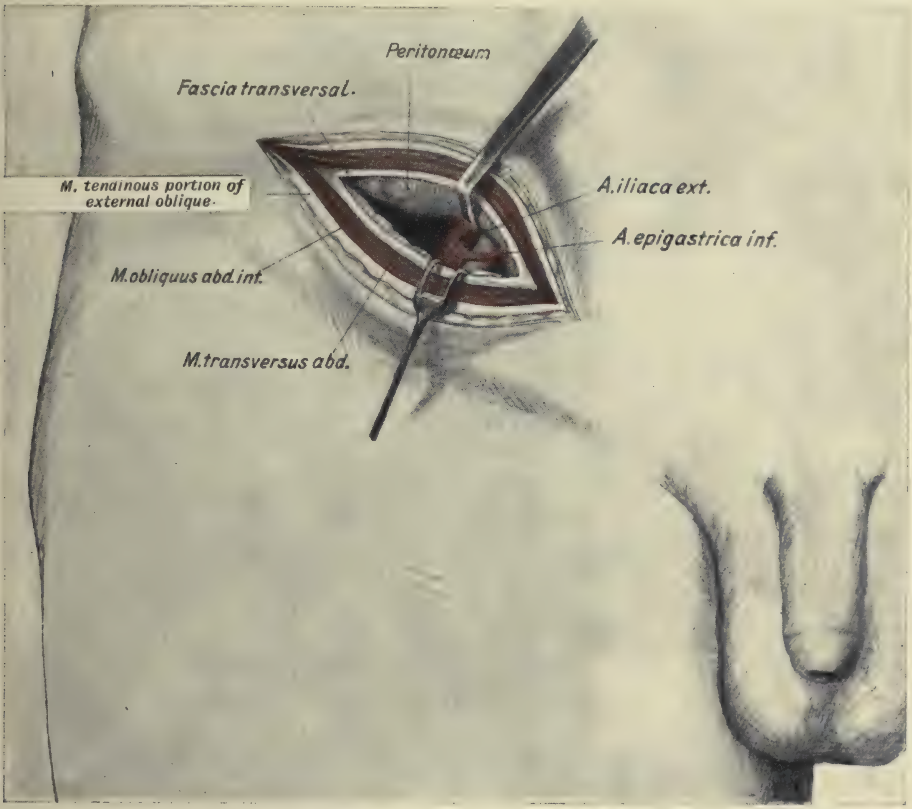

FIG. 10.—Exposure of the external iliac artery.

Common Iliac Artery.

The next step is to follow the external iliac upwards. Enlarge the incision till it reaches a point three finger-breadths above the anterior superior spine (see Fig. 9*b*), dividing the three abdominal muscles and the fascia transversalis to correspond. Assisted by elevation of the pelvis, displace the shut peritoneal sac still further in the direction of the umbilicus and get an assistant to draw it upwards with his hand. In doing this we also displace the ureter, which adheres closely to the back of the peritoneum; it crosses the common iliac near its point of division at or about the sacro-iliac synchondrosis. The spermatic cord is pushed forward in like manner. Proceed upwards above the point where the common iliac stem divides and encircle it with an aneurism needle, passing it on the right side from without and on the left side from within, to suit the position of the vein as already described. This completes the ligature.

Finally, if the student wishes to proceed along this line, he can ligature the internal iliac or even reach up to the abdominal aorta.

The ligature of the iliac artery and its main branches cannot be called difficult. Everything depends on recognizing the fascia transversalis as it is divided, and advancing along the correct layer. These operations are but seldom attempted, still their performance is important and instructive for an understanding of the topographical relations.

2. *Femoral Artery.*

The femoral artery makes its appearance from the vascular compartment by passing under Poupart's ligament; it then slants rather obliquely to the inside of the thigh and reaches back into the popliteal space with a course that is spiral relatively to the femur. The femoral vein accompanies it in its whole extent, lying to the inside of the artery at the level of Poupart's ligament but gradually assuming a posterior position as it is traced down. After emerging from Hunter's canal the vessels reappear at the back of the knee as the popliteal artery and vein. The term "femoral" artery is applied to the segment extending from Poupart's ligament to the point where it leaves Hunter's canal. The best way of explaining the course of the femoral is to project it on the skin with the thigh looking directly forwards; the line lies roughly parallel to the femur, and is drawn from the mid-inguinal point to the prominent "adductor" tubercule on the internal condyle of the femur. Below the inguinal fold it lies close under the skin but it rapidly sinks deeper as it descends. It runs first of all in the hollow between the ilio-psoas and pectineus muscles; it then lies on the adductor group and gives off the large trunk of the profunda femoris, which strikes deep at a point some three finger-breadths below the inguinal fold; it then runs with the femoral vein and long saphenous nerve in the furrow that separates the extensor from the adductor group of muscles; it finally disappears under the tendinous sheet which the adductor tendon sends to the femur at the junction of its mid and lower thirds. Of especial importance in the exposure of the vessel is its relation to the sartorius, as seen in Fig. 11. This muscle passes from the anterior superior spine to the inside of the head of the tibia and is easily recognized by its tendinous parallel fibres. It lies in a fascia lata sheath of its own. It crosses the femoral artery on its way down, so the artery had better be sought at the inner edge of the muscle when the incision is made above its centre, but at the outer side below that point. Further, in Fig. 11, we recognize the fascia lata radiating towards Poupart's ligament. An open window is left in it below the inguinal fold: this is the saphenous opening, the lower border of which is termed the inferior falciform process. The internal saphenous vein dips down over the edge of this process, and passes through the opening as a tributary of some size to join the femoral vein. The femoral vein always lies directly internal to the artery at this point. We shall study the typical ligature of the femoral artery at three points :—

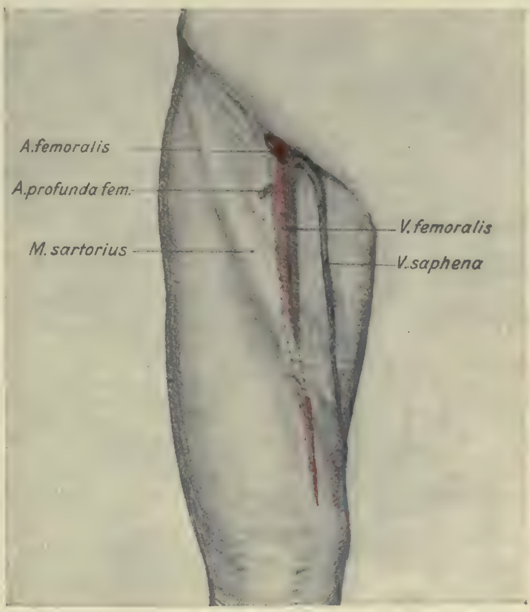

FIG. 11.—The fascia lata and the saphenous opening; the relation of the femoral artery to the sartorius muscle; the internal saphenous vein.

(*a*) below Poupart's ligament (in Scarpa's triangle), above the profunda femoris;

(*b*) in the middle third, below the profunda femoris;

(*c*) in Hunter's canal ("adductor" canal).

The three corresponding incisions are represented in Fig. 12.

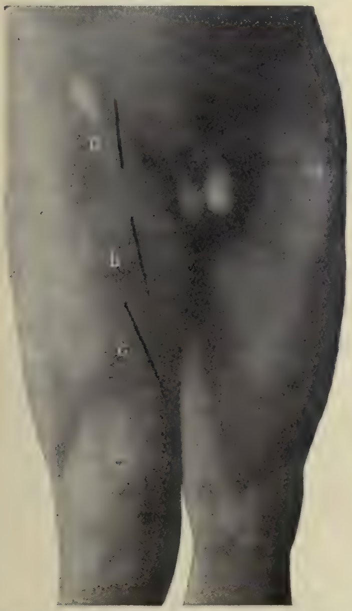

FIG. 12.—The femoral artery: incision and exposure. (*a*) Below Poupart's ligament; (*b*) in the middle third; (*c*) in Hunter's canal.

(*a*) *Ligature in Scarpa's triangle.*

The incision for this operation measures 2½ ins. to 3¼ ins. (6–8 cms.) in length. It begins about the middle of Poupart's ligament, and descends along the course of the artery as shown in the diagram. As soon as the skin and superficial tissue are divided (together with some superficial veins), you either strike the fascia lata at once and see the falciform process or are obliged to dissect on slowly through the superficial fat and associated lymph glands. You then start from the inferior falciform process and divide the fascia lata downwards in the line of the primary incision and thereby open the sheath of the femoral vessels, here very superficial. The artery lies to the outside; in the subject it looks like an elastic band and is usually found empty, whereas the vein is almost always full and markedly distended. The passage of the ligature gives no trouble. The operation is represented in Fig. 13.

It is advisable to seize this opportunity of grasping the further anatomical relations. Carefully isolate the artery from the origin of the deep epigastric artery to the point at which the profunda femoris is given off. Recognize the superficial epigastric artery and the superficial pudic as they leave the main stem. Expose the falciform process on the inner side and there will be no difficulty in finding the largest tributary of the femoral vein, the internal saphenous vein, which should be left intact on the inner side of the primary incision. The anterior crural nerve, which lies in the muscular compartment before appearing from beneath Poupart's ligament, is shielded from view by the ilio-pectineal septum (cp. Fig. 263).

(*b*) *Ligature in mid third.*

The artery is to be sought about the mid third of the thigh. Begin by palpating the sartorius muscle, or better, plot its course from origin to insertion. One must remember in this connection that after the subject has lain on its back for some time the course of the muscle is different from what obtains in life; it sinks downwards, inwards and backwards, sagging into a distinct curve. The incision should be made at its inner edge, and if one strikes the substance of the muscle itself it should be displaced to the side and the sheath at the back of it exposed. On dividing this in the same line we come on the vessels: the artery not just external to the vein but already somewhat in front of it; the long saphenous nerve usually lies on the artery (*v.* Fig. 13. Refer also to Fig. 116 for the relation of the artery in mid thigh).

(*c*) *Ligature in Hunter's canal.*

Strongly rotate the leg outwards; then incise in the direction of the sartorius at the junction of the middle and lower thirds of the thigh, but

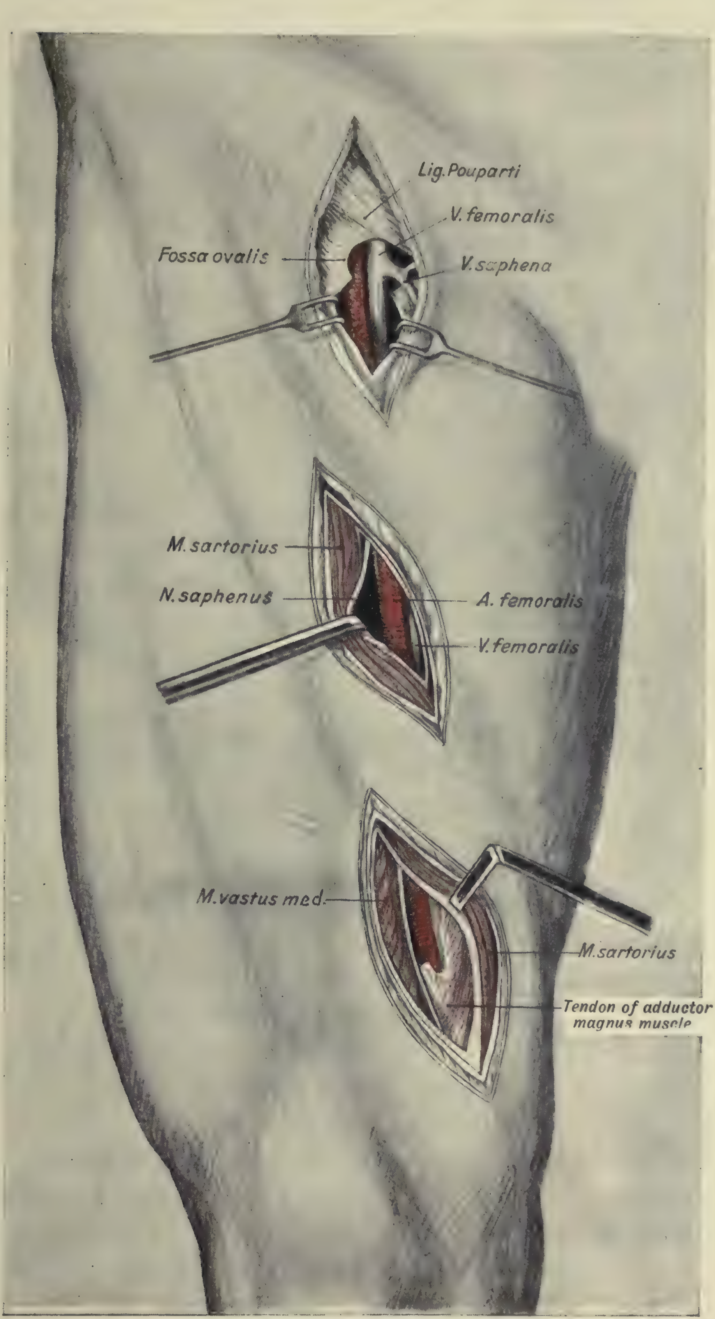

FIG. 13.—Exposure of the femoral artery below Poupart's ligament, in mid thigh and in Hunter's canal.

this time at the outer edge of the muscle ; pull it inwards out of the way (*v.* Figs. 12 and 13). Do not get lost among the adductor muscles, but take the vastus internus as a guide in the deep dissection : this muscle is recognized by its fibres running obliquely to the sartorius. The essential point is to find the shining tendinous sheet which connects the adductor tendon with the femur and vastus internus. This tendinous sheet forms the roof of Hunter's canal, and on splitting it on the line of incision, the main vessels make their appearance, the vein behind the artery (*v.* Fig. 13).

3. *Popliteal Artery.*

The ligature of the artery in the popliteal space is a very easy operation. We followed the femoral artery into Hunter's canal, and now we meet it again as the popliteal. It runs vertically and divides the diamond-shaped space at the back of the knee exactly into two halves. The popliteal vein has been gradually assuming a position definitely posterior to the artery, and it is therefore found overlapping the latter when we open from the back. The internal popliteal nerve is found lying on the vein : it is the main continuation of the sciatic nerve. The sciatic nerve courses by itself at the back of the thigh, gives off the external popliteal nerve above the popliteal space and finally becomes associated in the space itself with the popliteal vessels : the external popliteal nerve is about the same size as the internal and runs downwards and outwards from it.

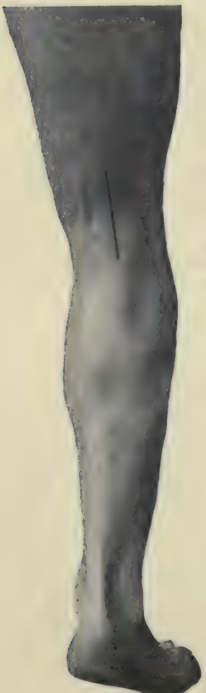
FIG. 14.—Popliteal artery : incision.

The body lies prone and the leg is extended. Palpate the outlines of the bones and muscles at the back of the knee and down into the diamond space ; it is quite easy to do so, at any rate in thin individuals.

The boundaries of the space are formed as follows :—below, the two heads of the gastrocnemius, and above, on the outside the biceps and on the inside the semitendinosus and semimembranosus tendons ; the plantaris muscle is associated with the external belly of the gastrocnemius. We incise vertically through the middle of the popliteal space (*v.* Fig. 14), avoiding the short saphenous vein where it lies in the subcutaneous tissue ; on cutting through the fat we come upon the deep fascia—quite tense in extension of the limb. On dividing this in the line of incision and retracting firmly we find all the soft parts of the popliteal space lying embedded in abundant fat ; the internal popliteal nerve is seen lying close under the fascia and somewhat to the outer side : pull it further outwards. Immediately under the nerve we come upon the popliteal vein, and alongside it and in a sheath common to both, the artery : the artery lies deep near the joint capsule, and looks out from under the inner side of the vein. Isolate it carefully from the vein and ligature it with an aneurism needle. After ligation, it is as well to utilize the incision to trace the internal popliteal further upwards, till we come upon the sciatic nerve dividing into internal and external popliteal nerves. The latter leaves the common stem in an outward direction and runs down to behind the head of the fibula.

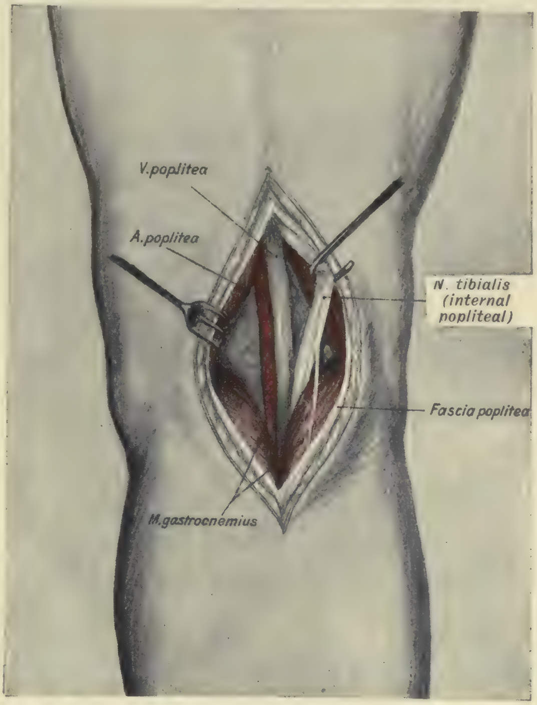

FIG. 15.—Right popliteal artery : exposure.

4. *Anterior Tibial Artery.*

The popliteal artery divides at the lower end of the popliteal space into anterior and posterior tibial arteries. The anterior passes through the interosseous membrane to the front and runs down on the membrane ; it is accompanied by the anterior tibial nerve which always lies to its outer side. Plot the course of the vessel on the skin, and it is seen to run vertically between the following two points :—above, midway between the tibial tubercule and the head of the fibula : below, midway between the two malleoli. A cross section (Fig. 108) gives one the best idea of the relation of the artery to the muscles : it is accessible in the intermuscular septum at the outer side of the tibialis anticus and it lies at a considerable depth.

(*a*) *Ligature in the muscular part of the leg at the junction of upper and middle thirds.*

The subject lies on the dorsum. Palpate the anterior edge of the tibia ;

the antero-internal tibial surface merges directly into this border and is felt immediately under the skin on the inside of the leg ; on the outer side we can palpate the tense extensor muscles, particularly the tibialis anticus, which lies immediately to the outside of the tibial border. This extensor is muscular and thicker than the thumb in its upper part, but becomes tendinous and as thin as a pencil close to the annular ligament. Incise parallel to and at its outer margin in the line already projected (Fig. 16*a*), and the tense aponeurosis comes at once into view ; it is here blended with the muscle tissue and hardly to be raised from it, and this makes it somewhat difficult to discover the first intermuscular septum. On finding it you must exercise firm retraction with two blunt hooks in order to bring the anterior tibial artery into view ; it lies between the tibialis anticus and the extensor communis digitorum. The artery, anterior tibial nerve and a few veins are associated in the one bundle ; it is difficult to ligature the artery alone on account of its depth (*v.* Fig. 17).

(*b*) *Ligature in the tendinous part of the leg just anterior to the bones.*

The longitudinal incision for this is depicted in Fig. 16*b*. Make it not more than a short finger-breadth out from the tibial border. The muscles are here easily movable under the fascia of the leg, and begin to take on a tendinous structure. The tendon next to the bone belongs to the tibialis anticus muscle, the second one to the extensor longus hallucis. Between these two there lies on the interosseous ligament the same vessel-nerve bundle that we found higher up ; there is equal difficulty in isolating the artery (Fig. 17).

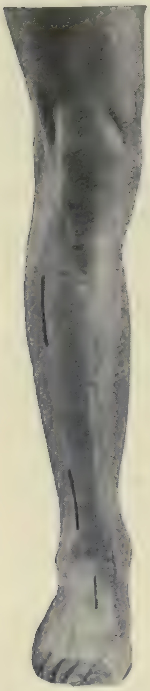

FIG. 16.—Anterior tibial artery : incisions (*a*) in the muscular part of the leg ; (*b*) in the tendinous part ; (*c*) for the dorsalis pedis artery.

5. *Arteria Dorsalis Pedis.*

This artery is the termination of the anterior tibial artery and is to be sought on the dorsum of the foot. It is exposed by the same incision as is used for exposing the extensor longus hallucis. The artery in the middle of the dorsum lies external to the tendon of the muscle ; the extensor longus hallucis crosses the vessel at a somewhat higher level close under the annular ligament. The drawing (Fig. 17) illustrates how the vessel and the neighbouring anterior tibial nerve come into view to the outside of the extensor tendon on division of the skin and fascia. The artery has to be raised with its venae comites as above described.

6. *Posterior Tibial Artery.*

The posterior tibial artery is directly continuous with the popliteal artery and lies deeply hidden below the muscles of the calf. Ligature in the upper part of the leg is neither easy nor of much practical value. But the anatomical relationships are of importance further down, where the artery runs behind the internal malleolus along with the other tendons: it lies fairly superficial between malleolus and tendo Achillis: its terminal branches supply the sole of the foot. It is of great importance for operations on the tendo Achillis and the ankle to know its position at the malleolus. It is accompanied by the posterior tibial nerve, which lies behind it.

(*a*) *Ligature in the muscles of the calf.*

As shown in Fig. 18*a* the attack is made at the inside of the leg. Palpate the surface of the tibia lying just under the skin and make an incision 1¼ ins. (3 cm.) in length behind the posterior tibial border and parallel to

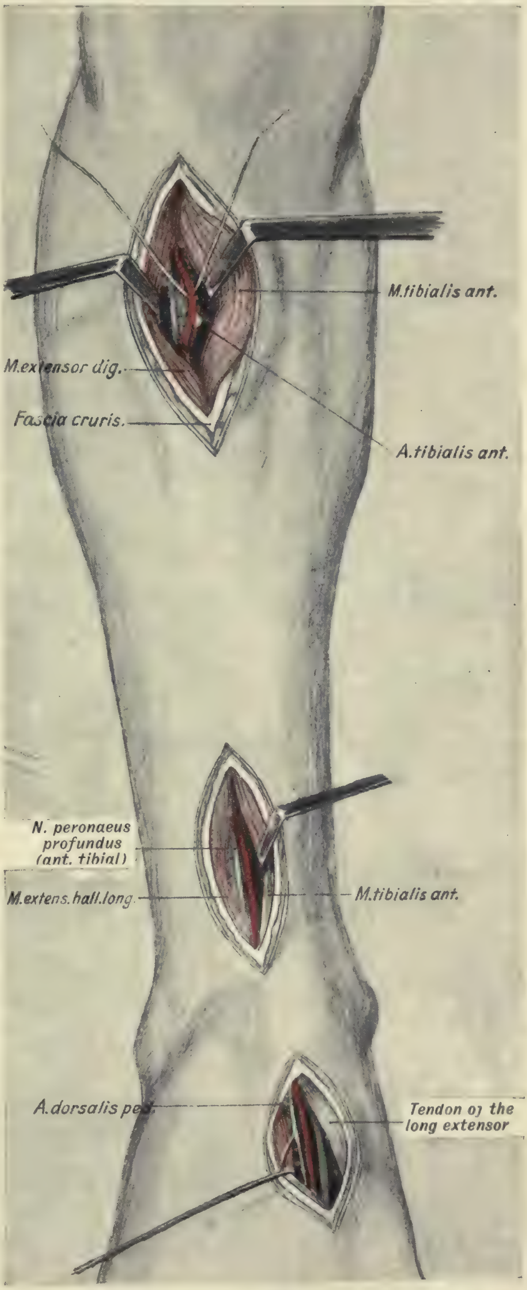

FIG. 17.—Exposure of the anterior tibial artery in the upper and lower thirds and exposure of the dorsalis pedis artery.

it. Divide the strong muscle aponeurosis just under the fat, seek the edge of the inner head of the gastrocnemius and draw it backwards. Divide the exposed soleus muscle in the direction of its fibres, till a thick fascial layer is seen. This covers in the deep flexors, the tibialis posticus muscle and the flexors of the toes. Divide the fascial layer in the line of incision and expose the vessel nerve bundle; isolate the artery from this, and ligature it (Fig. 19). It is best to use the cross section (Fig. 108) in order to understand the relations of the muscles and the line of operation.

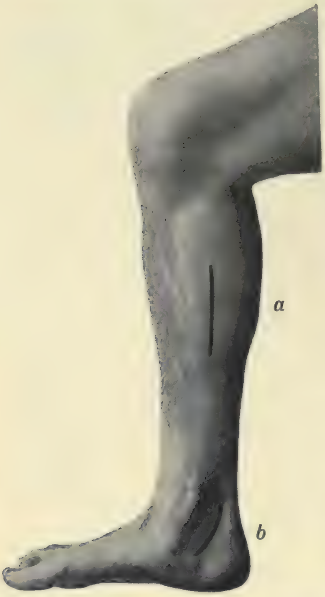

Fig. 18.—Posterior tibial artery: incisions (*a*) in the calf; (*b*) behind the internal malleolus.

(*b*) *Ligature in the tendinous part, at the internal malleolus.*

Make a somewhat curved incision round the lower end of the tibia, beginning midway between the bone and the tendo Achillis (*v.* Fig. 18*b*). Divide the fascia in the same direction and with care, for the posterior tibial artery is lying just behind it in fatty tissue, accompanied by veins. The posterior tibial nerve lies behind the artery. The sheath of the flexors which descend close behind the bone, remains unopened (Fig. 19).

B. The Carotid Artery and its Divisions.

1. *Common Carotid Artery.*

The innominate artery is the first large stem to spring from the arch of the aorta; after a brief course it divides behind the right sterno-clavicular articulation into the right common carotid and right subclavian arteries. The left carotid and subclavian usually spring directly from the arch. The carotids run almost vertically upwards. They mount on each side of the neck towards the skull, running almost parallel to the trachea (cp. Fig. 222). They are hidden by the muscles of the neck but their strong pulsation can be felt under ordinary conditions at the inner edge of the sterno-mastoid muscle; indeed, in spare individuals it is felt just above the sternal insertion of the muscles; the artery at this point is beating between the palpating finger and the carotid tubercule (transverse process of the 6th cervical vertebra). The inner edge of the sterno-mastoid is the guide to the carotid;

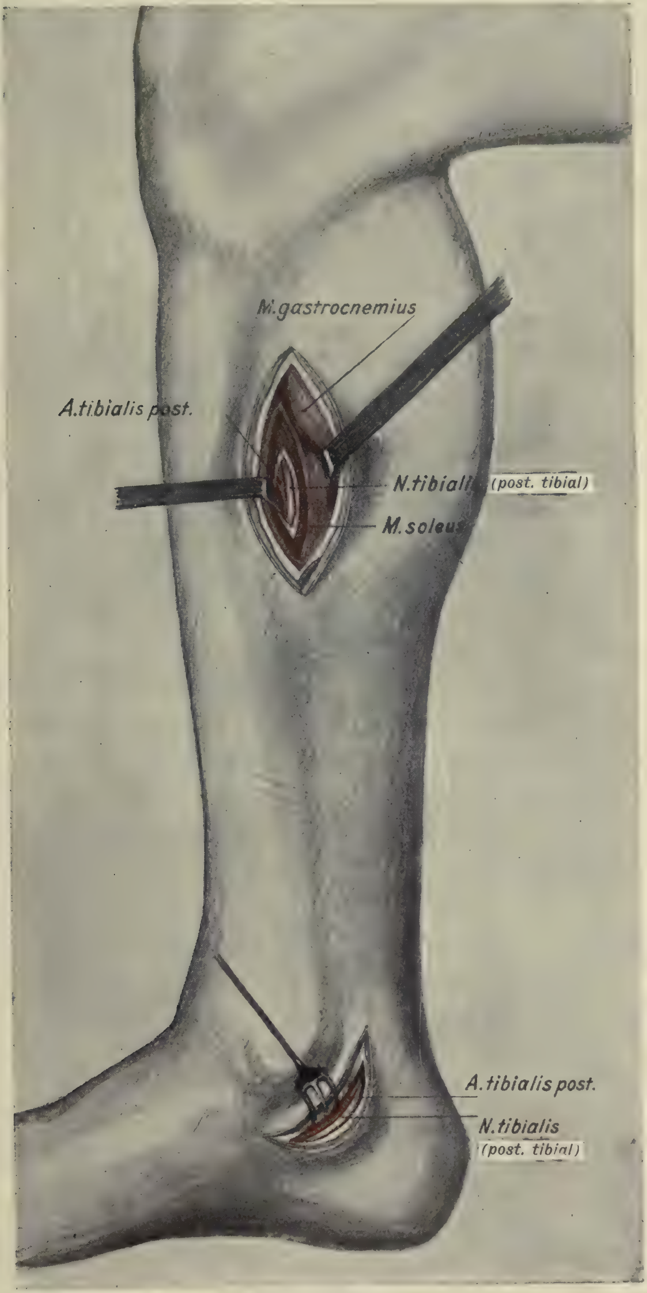

FIG. 19.—Exposure of the tibialis posticus artery in the calf and behind the internal malleolus.

though it is well to remember that the muscle crosses obliquely over the artery, overlapping it at its sternal insertion but gradually slanting outwards as it ascends.

At the level of the thyroid cartilage, and roughly speaking at its upper border, the artery divides into external and internal carotids. The internal jugular vein accompanies the artery and lies to its outer side in the middle of the neck. The degree to which it overlaps the artery varies with its form and size.

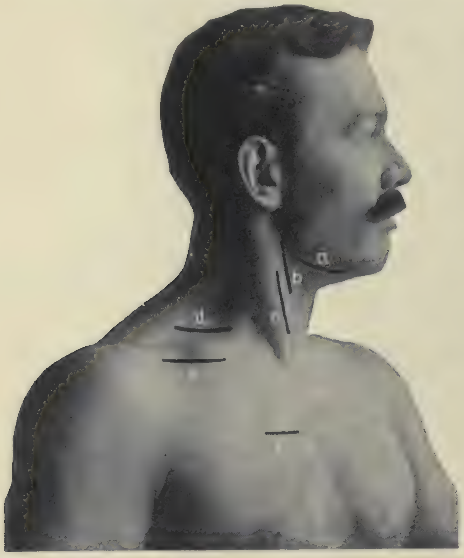

FIG. 20.—Incisions: (*a*) for the lingual artery; (*b*) for the carotid at its point of division and the superior thyroid artery; (*c*) for the common carotid stem and the inferior thyroid artery; (*d*) for the subclavian above the clavicle; (*e*) for the subclavian below the clavicle; (*f*) for the internal mammary artery.

Ligature of the common carotid is best attempted about an inch (2·5 cm.) below the point of division. In this way both the stem and the two branches are included in our search, and we get to learn the topography of a very important area. We are not at all anxious to ligature the common carotid artery in the living subject; temporary ligature or compression is preferable. If the brain is deprived of the blood supply severe cerebral lesions are apt to result, more especially in elderly people. Bend back and fix the head of the subject by means of a cushion, turning the face to the sound side. Palpate the clavicle and the lower jaw, then palpate the thyroid cartilage, the hyoid bone and the cricoid cartilage and the anterior edge of the sterno-mastoid muscle. Carry a longitudinal cut (*v.* Fig. 20*b*) along this anterior edge through skin and platysma, till the inner border of the muscle is exposed. The beginner had better lay bare the anatomical relations with a longer incision than is absolutely necessary. The incision begins at the level of the hyoid bone and ends below the level of the cricoid cartilage. The external jugular vein is met with in the upper angle of the wound lying in the subcutaneous tissue and ought as a rule to escape injury. Retract the sterno-mastoid to one side with a blunt hook, and divide the common sheath that surrounds the large vessels of the neck. The common carotid artery now presents in the angle between the sterno-mastoid and omo-hyoid muscles ; a slender nerve, the ramus descendens hypoglossi, lies in front of it, and the jugular vein is at its outer side. Cautiously separate the two vessels and the large vagus nerve is seen lying between and behind them. Take an aneurism needle and ligature the common carotid artery, avoiding all the adjacent structures. The anatomical relations are shown in Fig. 21.

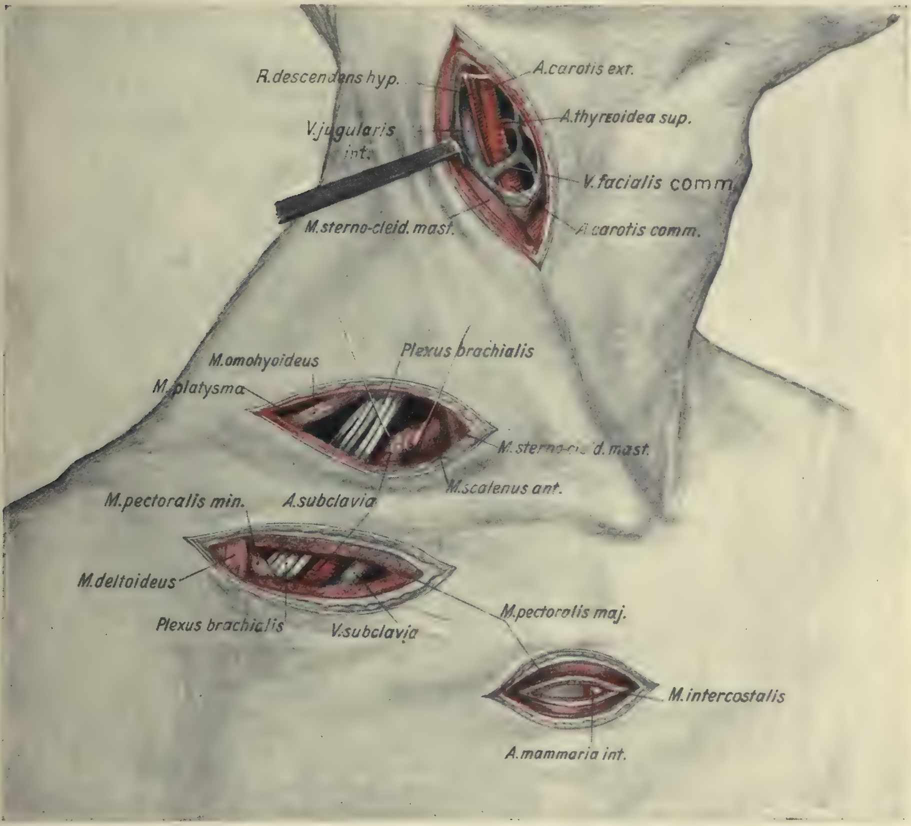

FIG. 21.—Exposure of the common carotid and external and internal carotid arteries, the superior thyroid artery, the subclavian artery above and below the clavicle and the internal mammary artery.

2. *External and Internal Carotid Arteries.*

Use the same incision as in the last description (Fig. 20*b*). Draw the upper half of the wound apart with retractors, and follow the stem of the carotid upwards till the point of division is reached at the level of the thyroid incisura. The artery is generally overlapped by a large vein that opens into the internal jugular, the common facial vein. If this is resting just where the main artery divides, it will need to be ligatured and divided before complete exposure of the two carotid stems is possible. But all that is usually wanted in simple ligature of the external or internal carotids is to push the vein to the side; note that it often breaks into branches above or below this point. The external carotid artery strikes inwards and forwards from the common carotid and is best recognized by its giving off several stout side branches just beyond the carotid forking. These are directed inwards and the first of them is the superior thyroid artery. The internal carotid artery runs deep so as to lie on the outside of the external carotid. Ligature is an easy matter at this point, just above the carotid forking. The common sheath must again be divided before the vessel can be exposed. Take care not to include the adjacent thin-walled veins in the ligature, nor the vagus and descendens hypoglossi nerves.

3. *Superior Thyroid Artery.*

No minute description is needed for mastering the technique of this typical and useful ligation, if the operator has learnt how to expose the carotid artery and its two main divisions. Fig. 21 shows how the superior thyroid artery issues from the external carotid just above the carotid bifurcation and immediately turns down towards the upper pole of the thyroid gland.

Expose the external carotid with a longitudinal cut (Fig. 20*b*) at the anterior border of the sterno-mastoid muscle as above described, and the superior thyroid artery cannot be missed. It is easily ligatured at its origin.

4. *Inferior Thyroid Artery.*

The incision for this artery (Fig. 20*c*) exposes the common carotid at the same time, but at a somewhat lower level. The inferior thyroid artery arises not from the carotid, however, but from the subclavian as one of the branches of the thyroid axis (*v.* Fig. 222). It runs upwards behind the carotid sheath, *i.e.* behind the main vessels and nerves of the neck; it then turns downwards and inwards to the thyroid gland; immediately before entering the gland it crosses over the inferior (or recurrent) laryngeal nerve, which runs upwards between the trachea and the oesophagus. The incision for the isolated ligature of the inferior thyroid artery can be seen from Figs. 20*c* and 22. The skin and platysma are divided as before and the inner border of the sterno-mastoid muscle exposed. The incision extends from the thyroid cartilage to the lower insertion of the sterno-mastoid. Expose the obliquely running omo-hyoid muscle and displace it upwards. Pull the edge of the sterno-mastoid well outwards, and the sterno-hyoid and sterno-thyroid muscles well inwards; the latter delimit the inner edge of the wound and should be retracted inwards along with the underlying lateral surface of the thyroid gland. This exposes the common sheath of the cervical vessels; on division of the sheath at the inner edge of the common carotid artery the inferior thyroid artery may be exposed. It is found running with the inferior thyroid vein across the neck to reach the thyroid gland; it passes behind the common carotid artery: near the trachea it crosses the important recurrent laryngeal nerve, which must be avoided at all costs (Fig. 22).

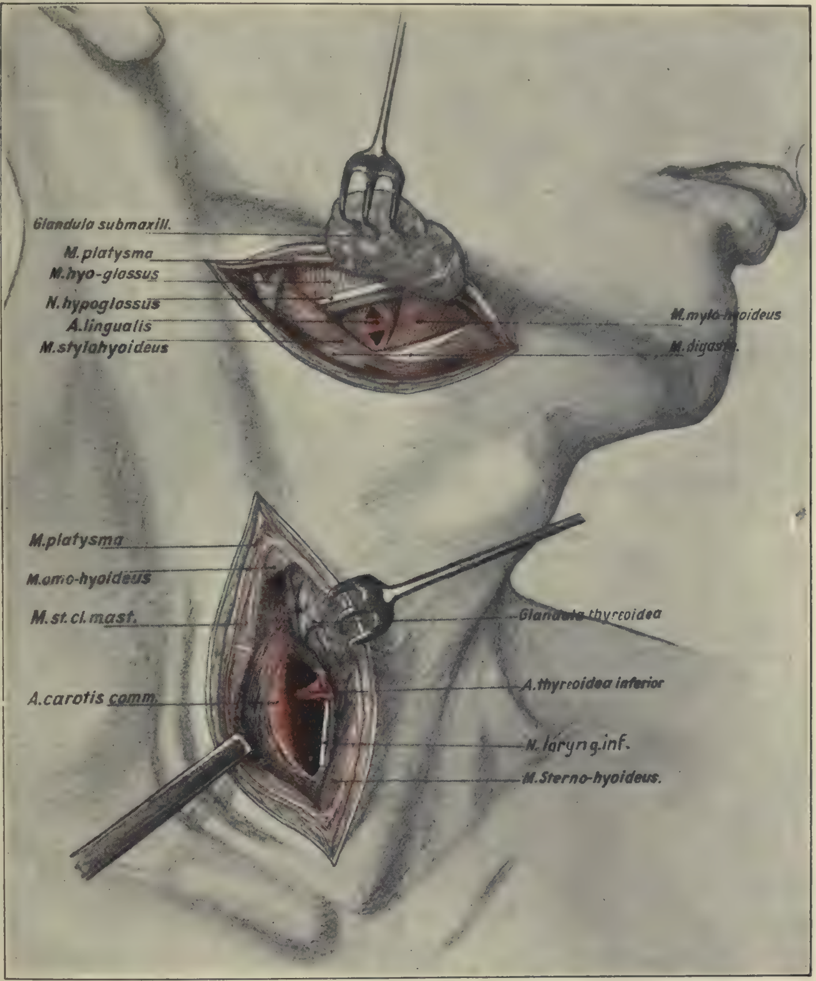

FIG. 22.—Exposure of the lingual artery, the common carotid artery and the inferior thyroid artery.

5. *Lingual Artery.*

Ligature of the lingual demands very great care. It is to be undertaken only after you are thoroughly cognizant with the anatomical relationships. To these you must rigidly adhere. The lingual artery is ligatured on one or both sides, with a view to limiting the loss of blood in major operations on the tongue.

The artery is a branch of the external carotid, and crosses inwards behind the great cornu of the hyoid bone, slanting upwards as it goes, and thence passes upwards to the tongue. Above the hyoid bone, it is sought in the deep, hypoglossal triangle, where boundaries are (1) the hypoglossal nerve ; (2) the posterior belly of the digastric and the stylo-hyoid muscles ; and (3) the mylo-hyoid muscle (cp. Fig. 22).

Place the subject as in operating on the carotid, with the head drawn back and to the left. Palpate the lower border of the horizontal ramus of the jaw. Make the incision roughly parallel to this, its convexity downwards and a finger's-breadth below the edge of the bone (*v.* Fig. 20*a*). On dividing skin and platysma, the external jugular vein is found lying in the posterior angle of the wound but is to be avoided. Retract the edges of the wound and the submaxillary gland covered by the deep cervical fascia will be seen to form its floor. Now divide the fascia, free the lower edge of the gland, and displace it upwards over the lower edge of the jaw, so that its deep prolongation is put well upon the stretch. The digastric muscle, with its tendinous attachment to the hyoid bone, now comes clearly into view ; the stylo-hyoid muscle is also inserted into the hyoid, and runs along with the posterior belly of the digastric. The mylo-hyoid muscle is seen in the anterior angle of the wound, extending from hyoid bone to mandible : its fibres become very evident when a fine, sharp hook is inserted at the pulley between the two bellies of the digastric and the hyoid bone drawn downwards. The hypoglossal nerve runs almost parallel to the hyoid bone and is now clearly seen, accompanied by the lingual vein ; it lies directly on the hyo-glossus muscle. The hyo-glossus fibres are longitudinal and form the background of a clear picture. Proceed to separate the fibres of the hyo-glossus with a pair of dissecting forceps, in the middle of the deep hypoglossal triangle. The artery is found underneath the muscle running horizontally. Raise it out on a small aneurism needle and ligature it.

The ligature of the lingual artery must be all the more carefully performed, as it is of the utmost surgical importance.

C. Subclavian Artery with its Branches.

1. *Subclavian Artery.*

The ligature of the large subclavian artery is not so simple. The subclavian arises from the arch of the aorta on the left side, and from the innominate artery on the right side. It leaves the thoracic outlet by arching over the first rib and proceeds directly into the axilla, passing obliquely outwards under the clavicle. The direction of the artery is got by drawing a line from the larynx to the axilla; the artery lies under the clavicle at the point where the line crosses the bone. It may be sought in either the supraclavicular or infraclavicular fossa. The subclavian vein accompanies it in its whole extent, and lies to its inner side; the great brachial plexus lies to its outer side, running to meet it in the supraclavicular fossa. The artery is thus placed between plexus and vein.

(*a*) *Ligature above the clavicle.*

To render the artery more accessible, place the subject on its back and strongly abduct the arm and clavicle outwards. Make a horizontal incision through skin and platysma $\frac{3}{8}$ in. (1 cm.) above the clavicle. This cut should extend from the outer border of the sterno-mastoid anteriorly to the outer end of the clavicle externally. The external jugular vein should be ligatured in two places and divided; it lies in the subcutaneous fat, but we not infrequently find it below the cervical fascia, for it frequently pierces the fascia first of all in the neighbourhood of the incision. Divide the fascia and make a blunt dissection with dissecting forceps through the fatty glandular tissue of the supraclavicular fossa. There are many blood-vessels, but, with care, we can keep our picture from being spoiled with needless hæmorrhage. Divide the deeper layer of the cervical fascia, expose the lower edge of the slender omo-hyoid muscle, and bring the thick yellow-white cords of the brachial plexus into view in the depths of the wound. In the living body it will now be easy to probe in deep and reach the pulsating artery, and to pass an aneurism needle under the guidance of the finger-tip. In the subject, the next step is to expose the outer edge of the scalenus anticus muscle; this can be recognized by its shining tendinous insertion. The course of this muscle is somewhat more vertical than that of the sterno-mastoid; it is inserted to the scalene tubercule of the 1st rib (tuberculum Lisfranci), which can be felt through the muscle. The subclavian artery takes a curved course from behind the outer edge of the scalenus anticus to reach the inner side of the brachial plexus. The artery is found between the scalenus anticus and the brachial plexus (*v.* Fig. 21)

The subclavian vein mounts over the 1st rib further forward and at a lower level, between the sterno-mastoid and anterior scalene muscles, and usually does not come into view if the artery is exposed in the above manner. The operator must work warily in its vicinity, as unpleasant consequences attend injury either of it or of its large branches. In the operation area but at a somewhat higher level the subclavian artery gives off the thyroid axis, one of whose branches, the suprascapular artery, runs transversely across the path of operation. The whole area is very rich in blood vessels, especially in thin and easily torn veins, and care must therefore be exercised in drawing the adjacent muscles apart. Cautiously feel your way before passing the aneurism needle round the artery. The thoracic duct lies behind the artery on the left side and is thus exposed to danger. It should on no account be interfered with.

(*b*) *Ligature below the clavicle.*

Readier access is gained to the artery at this point by abducting and elevating the arm of the subject. This raises the clavicle. The incision is made transversely $\frac{3}{8}$ in. (1 cm.) below the lower border of the clavicle (*v.* Fig. 20*e*). The cut corresponds roughly to the mid third of the bone, and stops short laterally at the edge of the deltoid. It traverses at once skin and subcutaneous fat and enters the coarse muscle fibres of the pectoralis major, which is divided in its whole thickness in the whole length of the skin incision. We traverse the deep fascia below this and reach a very vascular fatty layer, whence we advance deeper by blunt dissection. This exposes the inner edge of the pectoralis minor, which slants sharply upwards to the coracoid process. Proceeding deeper at the inner edge of this muscle we meet the great cords of the brachial plexus. Further inwards we are guided to the great subclavian vein by the numerous stout veins which enter it at this point. We secure the subclavian artery between brachial plexus and vein at a considerable depth (*v.* Fig. 21).

Exposure of the subclavian artery, both above and below the clavicle, demands the exercise of most careful technique and should never be rushed, for the vessel lies deep in the fatty tissue and is hidden among a rich plexus of veins. In an emergency hæmorrhage, therefore, the most rational procedure is to cut the clavicle across quickly with a wire saw, insert blunt retraction hooks (*v.* Fig. 21) into the marrow on each side and draw the two halves apart. This is the only way of gaining access to a large stretch of the subclavian. This method should also be practised, so as to fix the topography in our mind.

2. *Internal Mammary Artery.*

The internal mammary artery runs on either side on the inside of the chest wall, close to and almost parallel with the inner edge of the sternum. It lies behind the intercostal muscles on the parietal pleura and is accompanied by its venae comites. It can be secured at various levels between the costal cartilage of the 2nd to the 5th ribs. Make a 2-in. (5 cm.) incision, beginning at the edge of the sternum and running it out transversely in the selected intercostal space (Fig. 20*f*). Divide the skin and the thin fascia below it. Then penetrate the pectoralis major fibres as far as possible by blunt dissection and proceed on, layer by layer, through the intercostal muscles. It is only when the intercostal spaces are unusually narrow that we are obliged to remove pieces of cartilage. Taking care to avoid any injury to the pleura, raise the artery along with the venae comites on an aneurism needle and ligature it (*v.* Fig. 21).

It is difficult to isolate the artery. For a careful expose of the artery it is as well to recollect that it lies very close to the sternum opposite the 2nd and 3rd costal cartilages, but recedes from it further down to a distance of about $\frac{3}{8}$ in. (1 cm.).

3. *Axillary Artery.*

The continuation of the subclavian artery goes by the name of the axillary; the artery then runs on in relation to the basilic furrow as the brachial. It is to be sought in the anterior part of the axilla, where its pulsation can easily be felt during life. It is here associated with the vein and the axillary nerves. Place the subject on its back and abduct the arm to a little more than a right angle (to abduct further makes the head of the humerus project into the axilla and interfere with the relations), and palpate the anterior and posterior axillary folds; these are mainly composed of muscles, the pectoralis major in front and the latissimus dorsi and teres major behind. The biceps runs out at an angle from under the edge of the pectoralis major. A small bit of the coraco-brachialis muscle is both palpable and visible as it crosses between the two limbs of the axillary angle; the inner border of the muscle should roughly correspond with the anterior limit of the axillary hair. Make a 2-in. incision (5 cm.) along this line (*v.* Fig. 23*a*). dividing the fascia covering the muscles and so exposing the edge of the coraco-brachialis. Now draw the edges of the wound well apart and the artery is brought into view; only take care in this connection not to get lost in the axillary fat but adhere to the lower border of the coraco-brachialis. In immediate relation to this border there lies a strong nerve-strand, from which the median nerve takes origin. The median is the largest nerve we encounter ; trace it up and see how it is formed by a fusion of branches from the brachial plexus. The musculo - cutaneous nerve is smaller and passes from view behind the coraco-brachialis muscle. The internal cutaneous nerve comes off the inner cord and runs at the inner border of the muscle. The ulnar nerve is not seen till the median is displaced outwards. Draw the ulnar nerve inwards and the axillary artery lies before us. The axillary vein is wide and prevents us from seeing the vessel at first, especially in the living subject ; it often completely overlaps the vessel-nerve bundle. The vein collapses downwards after death. The stout musculo-spiral nerve lies under the vein, and may be easily exhibited : it soon strikes deep and disappears (cp. Fig. 24). Instead of drawing the median and ulnar nerves apart, they may both be drawn inwards and the artery sought between them and the coraco-brachialis.

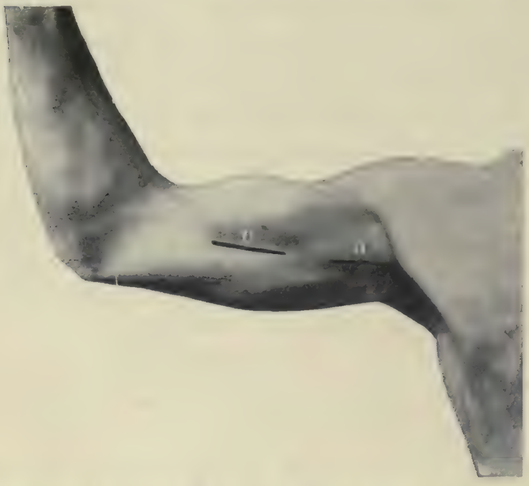

FIG. 23.—Incisions (*a*) for the axillary artery ; (*b*) for the brachial artery.

4. *Brachial Artery.*

The subject is placed in the same position as for exposure of the axillary artery, *i.e.* with arm abducted and hand supinated. The operator stands opposite the axilla and palpates the basilic furrow : it is always easily felt. It is also easy to make out the median nerve by rolling it as a firm cord under the finger-tips. The operator can palpate it on his own arm for control purposes. In the middle of the upper arm the nerve lies directly on the artery and forms the best guide to it. Half-way down the upper arm make a skin incision 2½ ins. (6 cm.) in length (*v.* Fig. 23*b*), and open the fascia covering the muscles. The vessel-nerve bundle will be found close under this fascia, still covered however by the deep and delicate vessel sheath. The beginner is apt to look for the structures long before he reaches their real depth. He should therefore keep close to the inner edge of the biceps and aim for the bone. He should avoid going too far backwards into the triceps musculature. The median nerve is easily found and is drawn backwards from the side of the muscle. The artery is found under the nerve. The brachial vein is in close association with it and at this level is represented by two branches. (Compare the section of the right upper arm, Fig. 91.) It is instructive to use this incision for understanding the position of the ulnar nerve. It is to be found on drawing the lower edge of the wound downwards. It is seen lying on the triceps, and runs in a slanting direction to the internal epicondyle at the elbow (cp. Fig. 24).

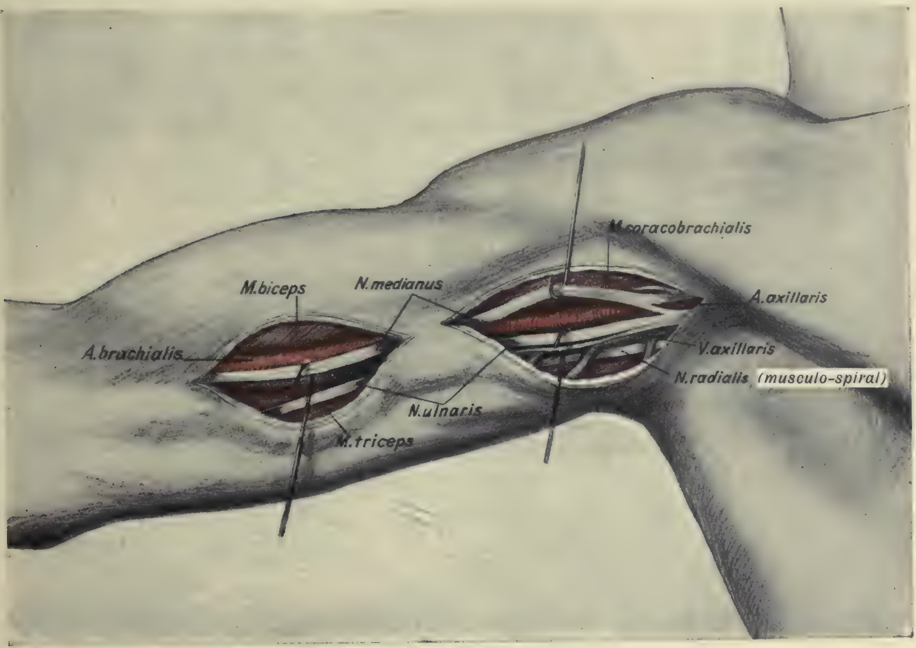

FIG. 24.—Exposure of the axillary and brachial arteries.

5. *Brachial Artery in Antecubital Space.*

The artery in its downward course keeps to the inner edge of the biceps muscle. It runs almost exactly in front of the middle of the elbow joint, which is covered by the brachialis anticus muscle. The arm is abducted and strongly supinated so as to bring the antecubital fossa to the front. Palpate the biceps tendon as it runs out from the muscle belly, and feel (try it on your own arm!) how it traverses the flexure of the elbow and disappears to gain a deep insertion on the radial tuberosity. Make a longitudinal cut through the flexure of the elbow at the inner edge of this tendon; the median vein here forms a bridge between the basilic and cephalic veins and is divided in the subcutaneous tissue. The biceps tendon is reached on division of the fascia, and the semilunar fascia exposed on retraction of the wound edges; this is a tendinous sheet that descends obliquely ulnarwards, radiating from the biceps tendon into the fascia of the forearm. This semilunar fascia is carefully divided in the line of the skin incision. The brachial artery with its venae comites lies just below it. The median nerve accompanies the artery right down the upper arm, but it diverges in the ulnar direction a little above the bend of the elbow (*v.* Fig. 26). In exposing the brachial artery at this point the beginner must note that it lies pretty near the skin, and so he should proceed slowly and warily layer by layer. Seize the opportunity presented by the incision to observe how the brachial divides into its radial and ulnar branches. This division occurs immediately below the spot where we have just exposed the artery The radial artery continues the direction of the brachial artery, runs obliquely across the pronator teres muscle and descends along the inner edge of the supinator longus. Not far from the brachial the radial gives off a strong side branch which runs towards the radial side. The ulnar artery leaves the brachial at a sharp angle, runs towards the ulnar side and disappears under the pronator teres and superficial flexors.

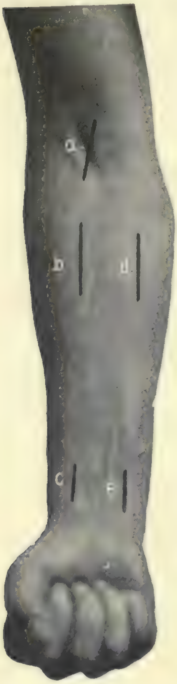

FIG. 25.—Incisions (*a*) for the brachial artery in the antecubital space; (*b*) and (*c*) for the radial artery; (*d*) and (*e*) for the ulnar artery.

6. *Radial Artery.*

All the important nerves and arteries lie on the flexor aspect of the forearm. On the extensor side the main structures covering the bones are the muscles, tendons and fasciae (cp. the cross section of mid forearm, Fig. 89). The radial and ulnar branches of the brachial are about the same size and both are sought in the corresponding muscular part of the forearm, either at the junction of the upper and middle thirds or in the tendinous part of the forearm just above the wrist. The requisite incisions can be made out from Fig. 24*b*, *c*, *d*, *e*. Recollect that the radial artery is a more or less direct continuation of the brachial, *i.e.* in a line that connects the middle of the bend of the elbow with the radial pulse at the wrist. The inner border of the supinator longus is a guide to the line of the artery; retract this muscle to the radial side.

(*a*) *Ligature in the muscular part.*

Supinate the forearm and incise at the junction of the upper and middle thirds of the forearm in the line as figured. Divide the strong fascia of the forearm to correspond. One should not press forward deeply till the inner edge of the supinator longus is clearly seen. Retract it towards the radial side and the artery will be easily found with its venae comites under a thin deep fascial layer (cp. Fig. 26). The slender and superficial radial nerve runs along with the artery at this point; not indeed in the immediate vicinity of the vessel, but a little to its outer side, hidden under the supinator longus.

(*b*) *Ligature at the wrist tendons.*

The operation is really one of the easiest in the whole series of artery ligations. Flex the hand at the wrist, and force up the tendon of the flexor carpi radialis. A furrow is left between the flexor tendon on the inside, and the supinator longus tendon on the outside; the tendons of the extensor ossis metacarpi pollicis and extensor primi internodii pollicis are associated with the supinator tendon in extension of the thumb. Let the operator compare this on his own wrist. Make a short linear cut in this furrow, and expose and divide the tense fascia of the forearm. The radial artery will then be found with its venae comites and can be ligatured. The radial nerve is not exposed, for it leaves the artery further up the arm (Fig. 26).

7. *Ulnar Artery.*

We left this vessel just below the point at which we ligatured the brachial artery. We next look for it at the radial border of the flexor carpi ulnaris muscle. After leaving the brachial at a sharp angle as above described, it passes under the flexor sublimis digitorum and takes a course more or less parallel to the radial artery: in its lower two thirds it lies in a line between the internal epicondyle of the humerus and the pisiform bone. It is in this line that the skin incisions are made (*v.* Fig. 25*d*, *e*).

(*a*) *Ligature in the muscular part.*

The incision should be a fairly long one, as shown in Fig. 25*d*, as the artery is deep and its ligation is difficult. Freely divide the fascia of the forearm and look for the somewhat tendinous border of the flexor carpi ulnaris, which lies well to the ulnar side. A mistake often made is to go too far into the middle of the forearm and get lost among the muscle fibres of the flexor sublimis digitorum. Having determined the edge of the correct muscle retract the flexor carpi ulnaris and the flexor sublimis digitorum apart, and the artery will be seen lying on the flexor profundus

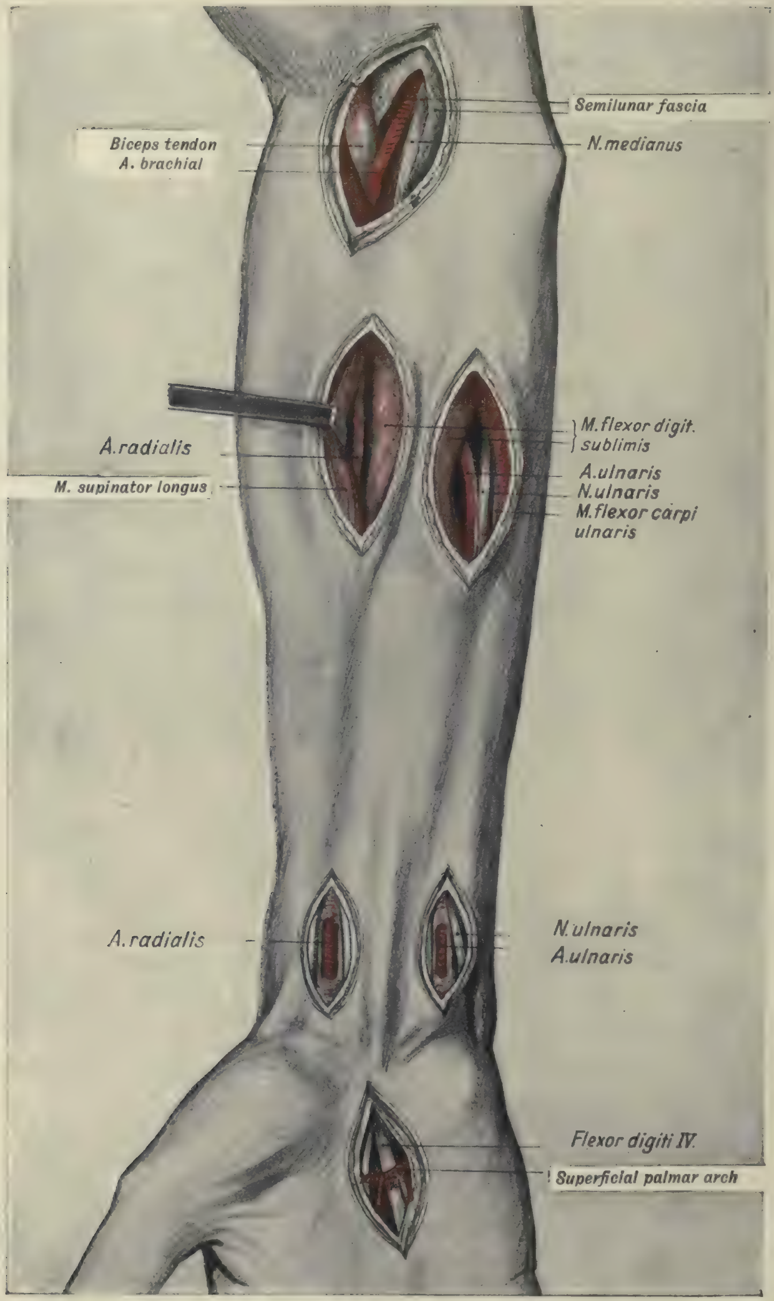

FIG. 26.—Exposure of the brachial artery in the antecubital space, of the radial and ulnar arteries in the muscular part of the forearm and at the wrist tendons; exposure of the superficial palmar arch.

digitorum. It is covered by a delicate and deep fascia, and has the ulnar nerve to its inside (*v.* Fig. 26).

(*b*) *Ligature at the wrist tendons.*

This ligature is also very easy. Start with a short incision along the outer edge of the flexor carpi ulnaris muscle (inserted into the pisiform bone). Then divide the fascia as in the case of the radial. The ulnar artery then comes into view with the ulnar nerve close to its inner side.

8. *Superficial Palmar Arch.*

Both radial and ulnar arteries form a palmar arch. The ulnar artery passes down in front of the anterior annular ligament. It then describes the superficial arch, which crosses the palmar surface transversely under the palmar aponeurosis. Its ligation will be described immediately. It gives off in its course the digital arteries, and ends by anastomosing with the superficial volar of the radial. The radial artery crosses the dorsum of the scaphoid and trapezium bones, returns to the palmar side in the 1st metacarpal space, between the first and second metacarpals, and then forms the deep palmar arch; we shall not describe its exposure.

The ligature of the superficial palmar arch is made through an incision that corresponds roughly to the course taken in the palm by the flexor tendon of the 4th finger. Extend the fingers to the full. Cut through the thick skin, the palmar aponeurosis and the richly fibrous fat of the palm; the fat pouts out in rather a troublesome way. Then work on carefully with the knife till the flexor tendons of the 4th finger appear. The superficial arch runs transversely across this tendon; its position is represented in Fig. 26. Secure the artery on an aneurism needle as far up as possible, and ligature it.[1]

---

[1] Palmar incisions should be made in the line of the aponeurosis and not across it.—TR.

SECTION II

EXCISION OF THE MAIN JOINTS

INTRODUCTION.—JOINT RESECTION IN GENERAL

EXCISION of joints forms one of the most important and instructive chapters in the operative surgery of the extremities. Excision was originally adopted to obviate the amputation of an entire limb in cases of joint disease. But the method has successfully solved not merely that problem alone, since time and deliberation have so moulded the method to completion that its application is becoming more and more indicated every day.

By the term RESECTION we mean an operation in which the continuity of a bone is broken in order to fit the remaining ends together in the most appropriate way. We use the word in the same sense when we speak of resecting the soft tissues of the body (*e.g.* the intestine, the ureters, etc.). By resection or excision of joints in the more restricted sense we understand the opening and extirpation of an entire joint. In contradistinction to this we use the word ARTHROTOMY to indicate the opening of a joint, *e.g.* in operating for a foreign body, so long as the joint structures are left intact and the joint cavity is not exposed to view in its entirety. ARTHRECTOMY means the deliberate opening and exposure of a joint followed by partial removal of the articular structures, *e.g.* the excision of part of the capsule or the complete removal of diseased foci from the articular cartilages or bones. This limited form of resection has latterly come into high favour: it is a conservative method and enables us to preserve a much larger measure of joint function than is got by complete excision. (In practice on the subject complete excision is the operation *par excellence*.) ARTHRODESIS is a special form of arthrectomy. We understand by this complete removal of articular cartilage with a view to artificial bony fixation, *e.g.* in paralyzed limbs. It only remains to state what we mean by temporary resection of bone. This betokens any operation in which an osteoplastic flap (of soft tissue and bone) is turned down to give access to the underlying parts; into this category there falls the temporary resection of the skull as a prelude to cranial operations, or the temporary displacement of the superior maxilla in exposing the throat, etc. The operation is then carried out and the temporarily disconnected bones (together with the soft tissue flap) are replaced in their normal position.

The first step in the typical excision of a joint is to make a skin incision which will fulfil two conditions. The exposure of the joint should be ample, and secondly, no reckless damage should be done to the neighbouring structures; in other words, the tendons, muscles, nerves and blood-vessels must be spared as far as possible. v. Langenbeck's directions are the best: namely, longitudinal incisions in the axis of the extremity. A number of sound methods are in existence for each important joint and are named after the authors. But generally we have found it impossible to describe more than one. We have therefore chosen the simplest and most essential incisions, the ones most frequently employed in the practice of surgery.

There can be no doubt that the success of an excision depends in large measure on how the first cut is made into the soft tissues. Accordingly the surgeon should never enter upon an excision without having a definite plan of action and he should always keep the topographical anatomy of the parts before his eyes. Nearly all the skin incisions are placed on the extensor aspect away from the main vessels: the latter lie on the flexor side and are hidden and protected by the soft tissues (groin, back of knee, axilla, antecubital space, wrist). The next step is to clear all the soft tissues from off the ends of the bones. A special set of instruments is used in this and the ensuing steps; they are shown in Figs. 27 to 45.

It is also necessary in every joint excision to have two assistants: one to hold the retractors, and the other to keep the limb fixed as you want it and particularly to exercise rotation in the excisions of the hip and shoulder joints. Assistants should be at hand even in operations on the subject and they should be trained men. The beginner is recommended to make use of a skeleton in getting up the excisions.

The operator is now equipped. He makes his cut into the soft tissues and begins to strip the fleshy flaps from both sides of the bone. He uses the so-called Resection-cuts; he keeps the knife turned directly towards the bone and lays cut after cut along it, retracting the soft tissues as he advances. It is sometimes quite easy to lever up the tissues with elevator or raspatory, but it is more difficult when the muscles and capsules have to be separated entirely from their insertions. It is possible in this way to perform a subperiosteal and subcapsular exposure and thus reduce bleeding and injury of the soft tissues to a minimum. In trying to safeguard the soft tissues it may be an advantage to remove the cortical and superficial layers of bone; they should be chiselled off at the places where the more important muscles are inserted, and left adherent to the muscle flaps (cp. olecranon, great trochanter of femur). The above is a conservative method and is only indicated if the joint capsule is sound and can be preserved. Another practice is followed in treating tubercule, viz. extracapsular

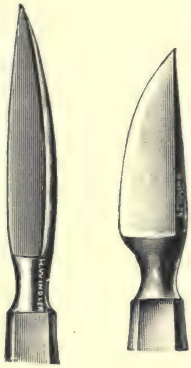

FIG. 27 and FIG. 28.
Resection knives.

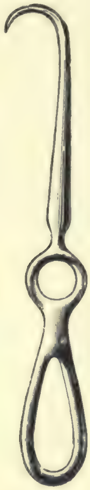

FIG. 29.
Langenbeck's sharp tenaculum.

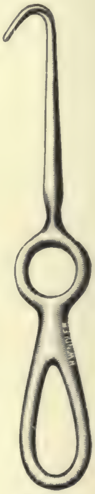

FIG. 30.
Blunt hook.

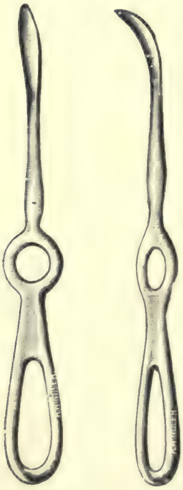

FIG. 31 and FIG. 32.
Elevators, straight and curved.

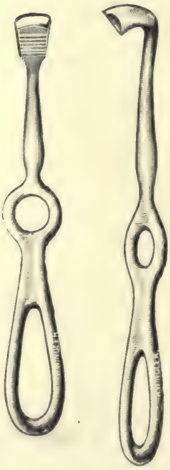

FIG. 33 and FIG. 34.
Raspatories, straight and curved.

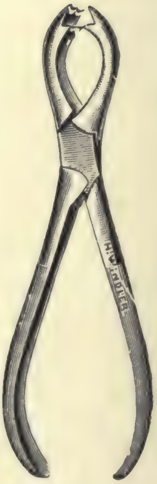

FIG. 35.
Bone forceps.

excision. If your technique be good, it is possible to excise *e.g.* a knee joint without ever opening the capsule. But the rule is to open the joint early; the bones are exposed, the remains of the capsule and joint ligaments are cut across and the joint allowed to spring open.

The third step is to remove the joint in its entirety. The bones are stripped of their periosteum and are gripped with lion forceps and sawn off with a bone or chain saw. Foci of disease are removed with gouge forceps or a sharp spoon. The third stage is completed by making a careful excision of the capsule. An extra strong excision forceps (toothed forceps) can be used with advantage for this purpose; carry the forceps in your left hand and manipulate the knife or scissors in your right.

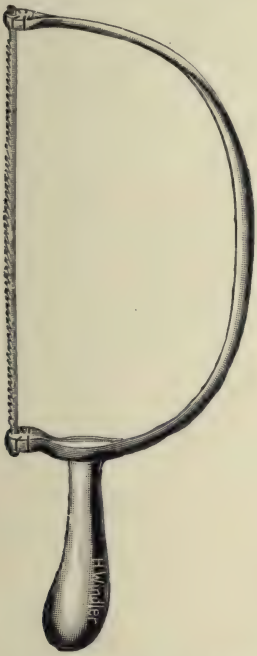

FIG. 36.—Butcher's saw.

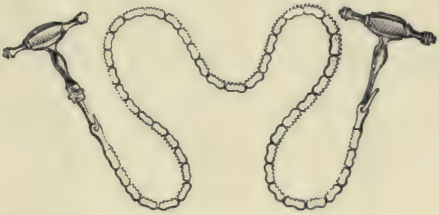

FIG. 37.—Chain saw.

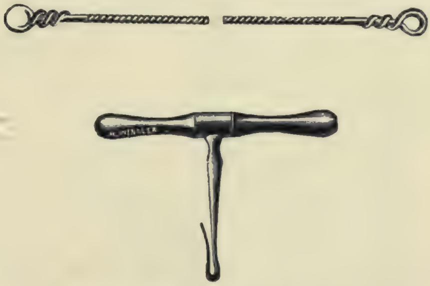

FIG. 38.—Gigli's wire saw and handle.

Before you attend to the wound in the fourth stage of the operation, you must have a clear idea as to whether you are aiming at the retention of a movable or a fixed joint. For complete fixation of the knee the joint must heal in extension, or the leg remains useless as a support. To secure fixation and for arthrodesis the bones are sutured with wire or catgut, or nailed together with bone pins as figured. For retention of a movable joint the excision is done sparingly, part of the capsule and the essential ligaments are left intact and movements are begun early; an extra effort should be made to secure mobility in the joints of the upper extremity. Articular surfaces are either left as they are, or the saw is made to follow the natural contours (Helferich's method), or soft tissues such as fat, fasciae and muscles are interposed so as to render bony ankylosis impossible. (In this connection cp. the chapter on excision of elbow, No. 3 in this part.) Whether the

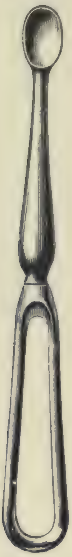

FIG. 39.—Sharp spoon.

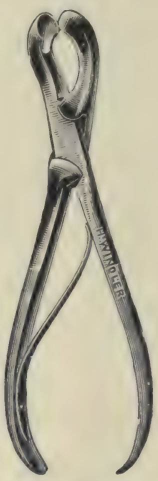

FIG. 40.—Rongeur forceps (Luer's).

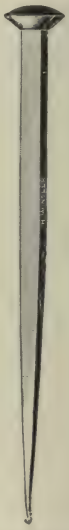

FIG. 41.—Bone pin.

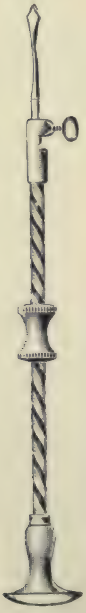

FIG. 42.—Bone borer.

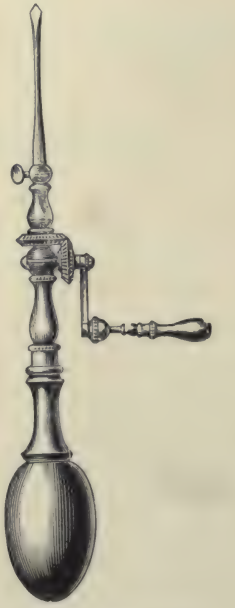

FIG. 43.—Bone borer.

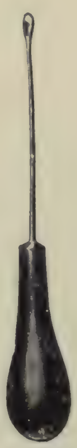

FIG. 44.—Wire carrier.

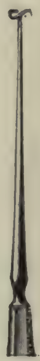

FIG. 45.—Wire twister.

suture of the wound shall be complete or partial, and whether drainage and counter-openings are to be employed, are points which must be decided from the condition of the joint (whether infected or not).

Finally, it is advisable for the beginner to make fairly large incisions when performing an excision on the subject, and to elevate away the soft tissues freely. Our illustrations are arranged to suit this idea. Of course in actual practice one has to incise and elevate less freely.

1. *Excision of the Wrist.*

Before proceeding to the excision of the wrist let us recall that the layer of soft tissue on the flexor aspect of the bone is considerably thicker than on the extensor side. Although we are debarred by this circumstance from attacking the wrist joint from the flexor aspect, it is equally true that the two arteries (radial and ulnar) and all three nerves (radial, median, and ulnar) lie on the flexor aspect (cp. the cross section, Fig. 89). We are thus obliged to incise either at the sides of the wrist or on the dorsum, where the only harm we can do is to the extensor tendons. The tendons run longitudinally all round the wrist joint and our incisions must be made parallel to them. Corresponding to the various interstices between the tendons there are many possible methods of excision, all of them quite good.

A diseased joint is not difficult to excise, especially if it has been destroyed by tubercule. Fistulae and abscesses are then present; they indicate the simplest path into the interior of the joint and direct us to the principal seat of disease; they quite often compel us to diverge from the usual method of operation. But in the subject the wrist joint is surrounded by tense ligaments; this obliges us to choose a way of access that affords us an opportunity of seeing and grasping the topographical relations. v. Langenbeck's dorso-radial incision is the one best suited for this purpose[1]

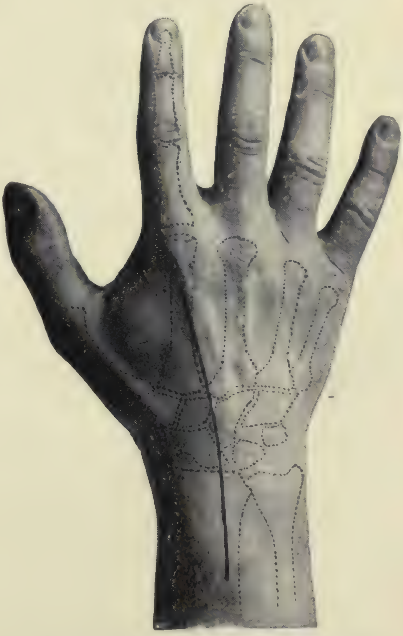

FIG. 46.—v. Langenbeck's dorsal incision for the resection of the wrist.

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[1] In Britain this incision is often associated with the name of Lister.—TR.

(Fig. 46). We should palpate the styloid processes of the radius and ulna on our own wrists and compare them with the corresponding points in the subject; we can then plot out the curved fissure that separates the forearm from the carpus. If we stretch our fingers out to the full, five extensor tendons will be seen to rise up and run under the dorsal ligament of the carpus, converging as they go. The best way to make the tendons stand out in the subject is to flex the wrist. The incision is a long one; it begins at the centre of the 2nd metacarpal, runs thence to the middle of the posterior carpal ligament and ends three finger-breadths above the wrist joint. This exposes the radial border of the extensor indicis tendon. After the division of the skin and subcutaneous tissue it will be noticed how the long extensor tendon of the thumb (extensor pollicis longus—extensor secundi internodii pollicis) crosses at a sharp angle over the tendons of the other fingers, running in a tunnel of its own. This obliquely running tendon must be exposed as far as its muscle fibres before we attempt to go any deeper; its tendinous tunnel on the posterior carpal ligament is thereby opened. The tendon is drawn to the side with a blunt hook to be out of danger. The posterior carpal ligament is now divided in the length of the skin incision, and all the extensor tendons belonging to the 2nd to the 5th fingers are drawn to the ulnar side. The insertions of the extensores carpi radialis longior et brevior into the bases of the 2nd and 3rd metacarpals come into view in the depths of the wound. It is to the ulnar side of these two tendons that we wish to carry the linear incision into the joint. Fig. 47 represents this stage of the operation.

The next step is to make the usual resection cuts, keeping the knife turned directly towards the bone, and displace the soft tissues well to right and left. All the tendons yield easily, coming out of their bed at once, with the exception of the extensor carpi radialis longior and still more the extensor carpi radialis brevior: their tendons are shorter and it requires the help of an elevator, or better, a chisel to raise them; they should retain their connection with the periosteum, as this enables them to adhere to the new position they are to occupy. This subperiosteal separation is continued till the styloid process of both radius and ulna are exposed. Flex the hand more and more until the wrist joint gapes open. Then divide the capsule transversely. Forcible palmar flexion gains us a view of both articular surfaces. After freeing the periosteum and soft tissues all round we saw off the diseased parts from radius and ulna. We then grasp the diseased carpal elements in turn with a small bone forceps and excise them. The operation is completed by the removal of the diseased capsule.

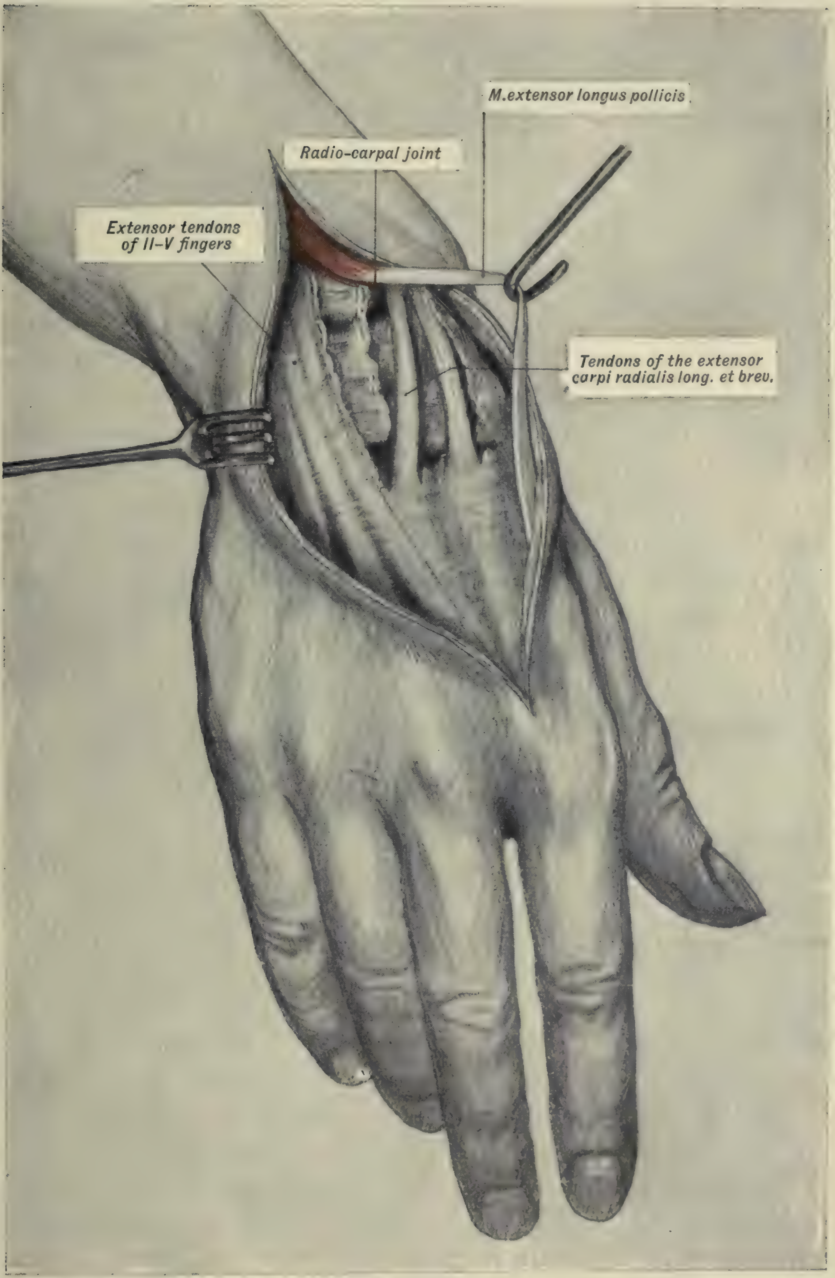
M.extensor longus pollicis
Radio-carpal joint
Extensor tendons of II–V fingers
Tendons of the extensor carpi radialis long. et brev.

FIG. 47.—Excision of the wrist; the joint-fissure has been exposed: the next stage is to free the soft tissues from the bones by means of resection cuts.

2. *Excision of the Ankle.*

The excision of the ankle is not inappropriately compared with that of the wrist. One function of the ankle is to support the body; accordingly the ligaments have to be much more rigid and the ends of the bones considerably more massive. Its mobility is distinctly less. The two malleoli, the counterparts of the styloid processes in the wrist, grasp the head of the astragalus much more firmly; they articulate only with the one bone, and render a conservative opening of the joint no easy task. The ankle joint like the wrist is surrounded by tendons, so we have to employ linear incisions and find it no easy task to work through between the tendons. The chapter on arterial ligations taught us the position of the two main arteries; the anterior tibial lying in front on the interosseous membrane, the posterior tibial on the inside between internal malleolus and tendo Achillis.

Many methods of excision are in vogue. Some aim at completing the operation without dividing any tendons and require several skin incisions; but this makes it a troublesome business to reach the joint and the method is not available in every instance. Accordingly, I consider the method of Lauenstein and Kocher to be the best. It proceeds as follows:—

Place the subject on the dorsum, rotate the leg inwards as far as possible and adduct the foot. An even better way is to turn the subject right on to the sound side. Palpate the lower end of the fibula and the external malleolus, and then carry a long curved incision round the malleolus. This incision runs $\frac{3}{8}$ in. (1 cm.) behind the posterior edge of the fibula and keeps at the same distance from the bone as it curves round the malleolus. It commences about 4 in. (10 cm.) above the tip of the malleolus, turns on to the dorsum of the foot and ends about a thumb's-breadth in front of the external malleolus (*v.* Fig. 48). The tendons of the peroneus longus and brevis are easily palpable and are to be exposed by deepening the cut; you then open the sheaths of these tendons close behind the fibula, run your cut upwards and downwards the whole length of the skin incision and lift the tendons out of their sheaths. Try to

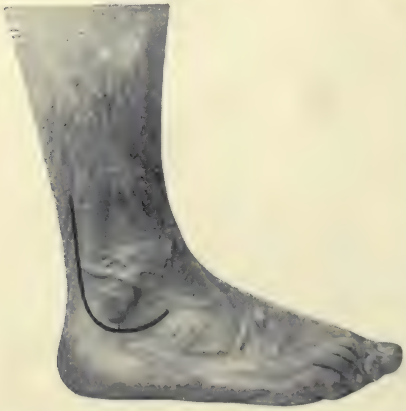

FIG. 48.—Lauenstein's and Kocher's incision in the resection of the ankle.

safeguard the tendons by drawing them to the side. It is well for the amateur in surgical technique to divide the two tendons at once, an essential step in all the more difficult excisions of the ankle. The divided tendons are each caught up in turns with sutures, so that there may be no difficulty in finding and uniting them later. The soft tissues are then divided in the line of incision right down to the bone and elevated in front and behind by means of the usual resection cuts. We first detach the soft tissues from the front and lever them from the outside of the fibula with knife and elevator: they are very adherent to the rough bone and should be kept well retracted as we proceed. On reaching the anterior surface of the malleolus we come on the astragalus and tibia: we then open the ankle joint for the first time and press on underneath the capsule. The anterior part of the head of the astragalus comes into view, and we

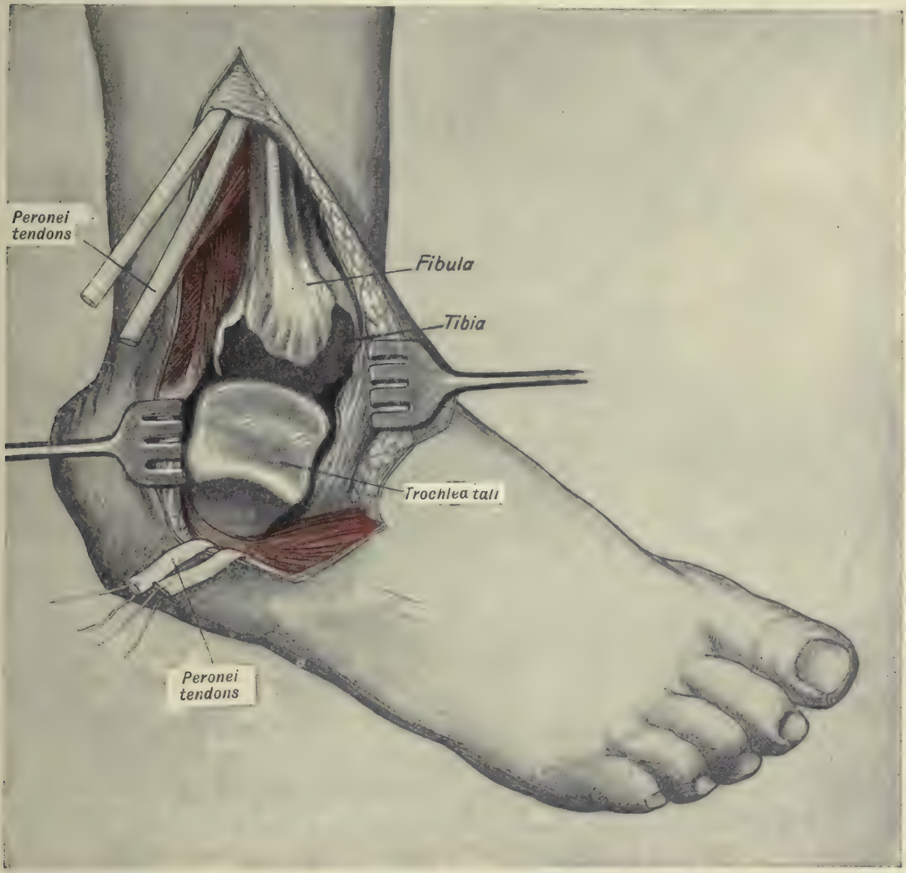

FIG. 49.—Excision of the ankle joint after Lauenstein and Kocher. The skin incision and the resection cuts are completed, and the joint thrown open.

proceed to lever up the extensor tendons almost as far round as the internal malleolus; if the capsule is diseased we do the levering outside of it, so that we work as nearly as possible through normal tissue. In the same way we lever the soft parts from the back of the joint, along the posterior edge of the tibia. Finally, we divide the ligaments and remains of the capsule that connect the external malleolus and tibia with the tarsal bones. The joint now gapes open. Fig. 49 represents this stage of the operation.

If good work has been made of the earlier separation, it will now be easy to wrench the foot inwards. This exposes the apposed articular surfaces, while the sole of the foot is made to look right upwards. The tibia is often broken in the process. Examine every part of the joint and remove all foci of disease from cartilage, bone and capsule; and never omit to examine the tibio-fibular cleft. Tubercule often settles in and spreads from the astragalus; it is therefore advisable to practise its excision at this stage. Grasp the trochlea tali with strong lion forceps and separate the bone all round from the tense ligaments that bind it to the scaphoid bone on the one side and the calcaneus on the other. This enables you to inspect the calcaneo-astragaloid and astragalo-scaphoid joints, just as in the case of the ankle joint itself. If the articular surfaces are found to be healthy, they may be left intact: but if the disease has progressed it may be necessary to remove the necrosed parts of the bone with saw, chisel, sharp spoon or gouge forceps. Our treatment in every case depends on the extent of the lesion.

The best functional results are obtained when the internal lateral ligament holds firm on the joint being wrenched open; this ensures immediate firm union after the foot has been replaced. But even if the ligament be divided, as is often required in astragalectomy, a good functional result and free mobility is frequently secured owing to the two malleoli entering into articulation with the surface of the calcaneus. A joint often forms in this way prior to the cessation of growth and it may display quite a considerable degree of mobility without ceasing to functionate as a support.

We have laid stress on this method of Lauenstein and Kocher, because the procedure can be easily understood. König's method occupies at least as important a position in the treatment of tubercular disease of the ankle. The excision is undertaken by means of two lateral linear incisions at the anterior border of each malleolus (*v.* Fig. 50).

Fig. 51 represents Hüter's dorsal incision.

This begins behind one malleolus, crosses the talo-crural joint and ends behind the other malleolus. It is an ideal method of opening the joint and can best be compared with the first stage of Pirogoff's osteoplastic amputation (Fig. 103); but all the extensor tendons are sacrificed, together with the dorsalis pedis artery and the cutaneous and anterior tibial nerves. The method should therefore be reserved for cases where there is complete paralysis of the foot and the joint is being opened for the production of arthrodesis (artificial fixation).

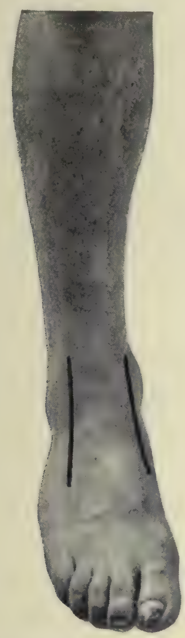

FIG. 50.—König's incisions.

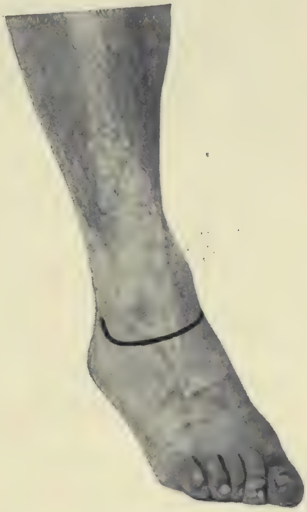

FIG. 51.—Hüter's incision for excision of the ankle.

APPENDIX A.

Osteoplastic Resection of the Ankle after Wládimiroff-Mikulicz.

In dealing with the excision of the ankle we might refer to a series of atypical methods all of which aim at removing disease limited to single bones. For the purposes of this course it is best to practise the most fruitful of all these operation methods, namely, the osteoplastic excision of the ankle by Wladimiroff-Mikulicz. This operation is indicated whenever the calcaneus is the seat of a malignant tumour or when all the tarsal bones have to be condemned on account of tuberculosis or severe crushing and the skin of the heel has been implicated and destroyed.

Fig. 52 represents the saw cuts made in the bone. One can remove the whole of the bone between *a* and *b*, or between *a* and *c*.

The operation is performed as follows: Place the subject in the prone position, and divide the tendo Achillis with a strong resection knife a thumb's-breadth above the level of the joint, cutting everything down to bone (Fig. 53). The second incision is made in the form of a stirrup through all the soft tissues of the sole at the level at which you purpose sawing the bone (*i.e.* at the scaphoid and cuboid bones or at the level of Lisfranc's joint. Cf. Fig. 98). Connect the ends of the two incisions by oblique incisions on each side, cutting right down to the bone. Now dorsiflex the foot strongly, thus making the incisions gape, and penetrate the ankle joint from behind. Open it right up and insert a single sharp hook into the head of the astragalus. Remove the astragalus and calcaneus. The disarticulation takes place at Chopart's joint, and the heel cap comes away with the bones (*v.* Fig. 98). Be careful to retract the extensor tendons and especially the anterior tibial artery, together with the soft parts on the dorsum of the foot: a bridge of tissue is thus preserved. On looking into the large wound one sees the tendo Achillis cut across and just internal to it the flexors of the toes and the posterior tibial muscle and artery: externally, the divided peroneal tendons. Still preserving the dorsal flap, proceed to expose the lower end of the tibia and then saw it across (line *a*, Fig. 52). In like manner lay bare the parts of

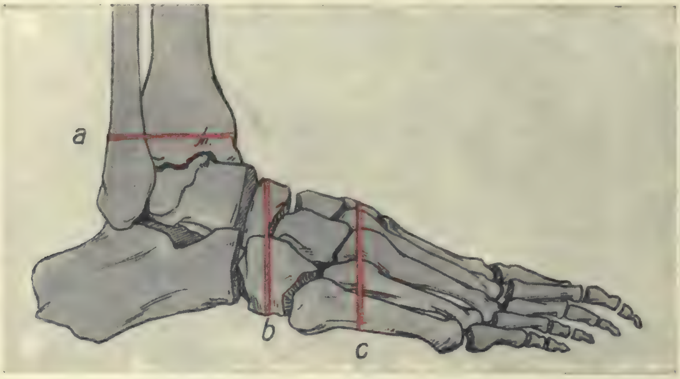

FIG. 52.—Osteoplastic resection of the ankle after Wladimiroff-Mikulicz: lines for saw (either between *a* and *b* or between *a* and *c*).

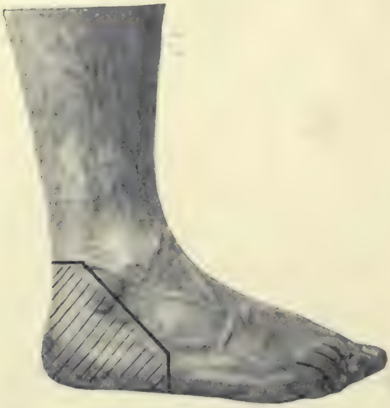

FIG. 53.—Incision in the Wladimiroff-Mikulicz osteoplastic resection of the ankle. The shaded area is removed.

the scaphoid and cuboid that project into the wound, avoiding any injury to the soft parts, and saw them through in the line of the original stirrup incision. If all the tarsal bones have been condemned, the saw-cut should be at the level of line *c* in Fig. 52, across the basis of the five metatarsals; you will have to expose the bones to a corresponding extent. If you now take and fold the two sawn surfaces on one another, a straight pointed foot is the result. Coapt the bony surfaces in this position with two wire sutures; reinforce with some deeply sunk sutures and stitch up the skin. The patient will walk upon the balls of the strongly extended toes.

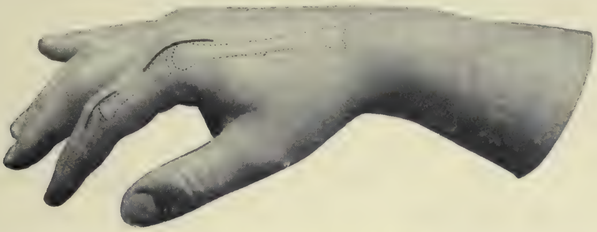

FIG. 54.—Incisions for the resection of the lesser joints of the hand.

APPENDIX B.

Excision of the small joints in Hand and Foot.

If one has assimilated the rules that apply to excision of joints in general there should be no difficulty in exposing and opening the smaller joints correctly. Never incise without a definite plan of campaign to avoid needless injury; do not infringe upon the grasping surface of the hand or the pressure surface of the foot. Linear incisions are the rule. Remember that it is the flexor sides of the projecting fingers and toes that contain the main nerves and vessels; so always choose lateral incisions, placing them well towards the dorsum and close to the extensor tendons for preference. The lateral incision is available in the cases of the 1st, 2nd, and 5th metacarpo-phalangeal joints, but a more dorsal cut is needed for the 3rd and 4th fingers; in the foot lateral incisions are suitable for the 1st and 5th toes. The continuity of the tendons need never be destroyed and good subperiosteal and subcapsular work saves at least some of those tense ligamentous structures that are of such importance for a functional result. When the nature of the disease demands it, it is possible to remove parts of the ligamentous structures or even the entire capsule. But guard against any unnecessary opening of the tendon sheaths, as these are very susceptible to infection. Free resections of the terminal finger joints are useless in practice; too often a functionless finger is the result and amputation is required later on. Some of the typical resection incisions are shown in Fig. 54.

3. *Excision of the Elbow Joint.*

An exact knowledge of the topography is more essential to the proper excision of the elbow than in the case of any other joint. A grip of the anatomy of the elbow enables us to respect the muscular insertions and conserve the fine outlines of the three bones that abut to form a triple articulation. We have to deal with an articulation between humerus and ulna, another between humerus and radius, and a third between radius and ulna: the last of these serves for the pronation and supination of the hand. The joint is a complicated one and it must not be opened until a careful palpation has been made of the characteristic bony points; the beginner should secure a skeleton and palpate the corresponding bones. The more immediate relations are got by locating the external and internal epicondyles. The internal lies a little further down the arm and juts like a thorn from the inner side of the humerus. The olecranon ulnae is placed on the extensor side and between the two epicondyles: it is directly continuous with the posterior border of the ulna, which is palpable in its whole length underneath the skin. The head of the radius can be felt under the skin immediately distal to the external condyle: it may be felt rotating on pronation and supination of the hand. All the important vessels and nerves lie on the flexor aspect with the exception of the ulnar nerve, which is to be carefully avoided throughout the whole operation. It leaves the vessels and nerves as they run down in the internal bicipital furrow and sweeps round the back of the internal epicondyle; at the level of the joint it is found on the extensor side, lying in the ulnar groove between the olecranon and the internal epicondyle, where it can easily be felt in a spare subject. (Cp. Figs. 56, 57, and 134.)

The operator stands on the affected side. The arm is folded over the breast of the subject, while an assistant stands opposite and holds the arm in mid flexion, thus enabling one to excise the joint in comfort. For a complete resection, v. Langenbeck's linear incision is the best (cp. Fig. 55). Use an excision knife and commence the incision on the ulnar border three finger-breadths below the olecranon. Carry the cut right down to the ulna at one sweep, thence over the olecranon, and continue it up a distance of at least three finger-breadths above that process. Force the knife deep into the olecranon fossa; its tip rests against the bone and it splits the triceps tendon into two halves at one stroke. Do not stop, but insert sharp retractors into the triceps muscle on each side and then gradually shell off all the soft tissues on the radial side by means of the usual resection cuts. The easiest way of keeping the soft parts intact is by chiselling off the external bony layers from the olecranon. A few more cuts, and we soon open into the radio-humeral joint. The head of the radius appears in the wound, and the soft parts are raised along with the periosteum in the form of a hood and levered over the external epicondyle. We do the same on the ulnar side. If we keep close to the bone the ulnar nerve will never be noticed, as it is lifted from its groove along with the rest of the soft tissues. Stripping up further we come to the internal epicondyle. Here we lay the chisel flat on the bone and strike off the superficial cortical layers; this enables the flexors of the forearm and fingers to retain their insertions. In raising the soft parts from the bones we use knife and elevator by turns. The end of this stage is shown in Fig. 56. The border of the ulna projects like a keel and some difficulty may be experienced in loosening the muscular insertions from the sides of the bone. (The ulnar nerve is shown exposed in Figs. 56 and 57, in order to establish the relations.) A few short cuts through the lateral ligaments and the joint is opened up to its full extent. It is then quite easy to lay bare the anterior aspect of the humerus. The whole of the lower epiphysis is now brought into view and it is possible to saw it off with the Butcher's saw. A fine blade is introduced and a curved saw-cut made in order to preserve the main outlines of the bone. The coronoid process of the ulna has then to be freed by removing part of the insertion of the brachialis anticus at the same time. We can also saw off the joint surfaces of radius and ulna, following the articular contour as we go. In doing so we make an extra effort to retain a hooked stump on the olecranon; this lets the triceps muscle regain its insertion, gives it some purchase and thus preserves its function. Every particle of the articular capsule should be extirpated. This completes the description of total excision.

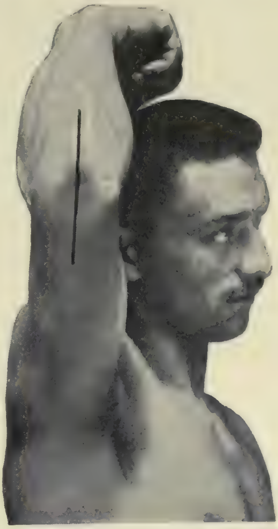
FIG. 55.—v. Langenbeck's incision for the resection of the elbow joint.

An elbow resected in this way will ultimately attain full function and mobility, provided movements are begun early in the course of after-treatment. The bones may fit one another all right, but there is a great danger of resecting their broad ends so sparingly that bony ankylosis soon

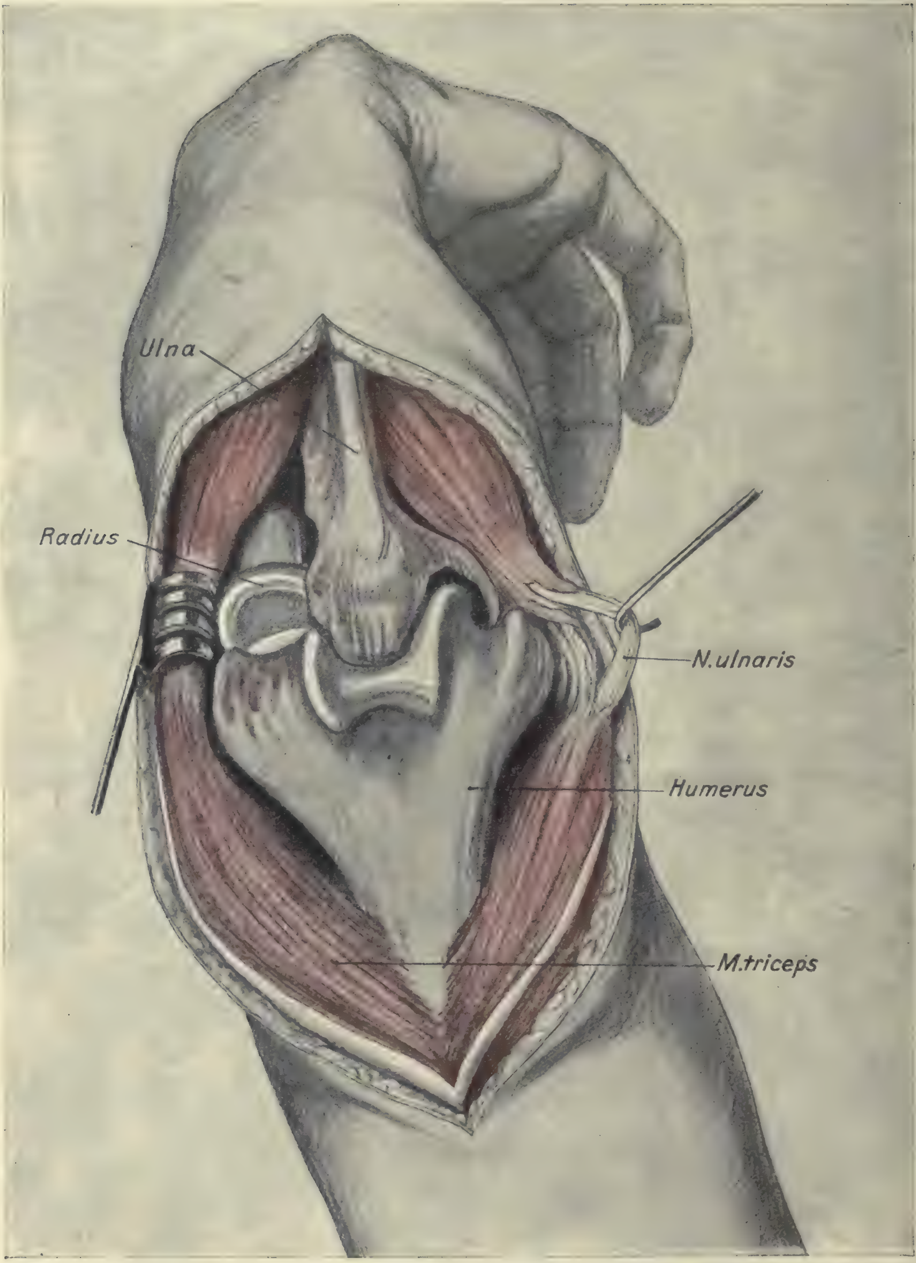

FIG. 56.—Excision of the elbow joint. Stage I. The soft tissues have been separated from the bones on either side by typical resection cuts. A very free exposure has been made for pictorial purposes, and for a similar reason the ulnar nerve has been pulled out of the soft tissues in which it lies.

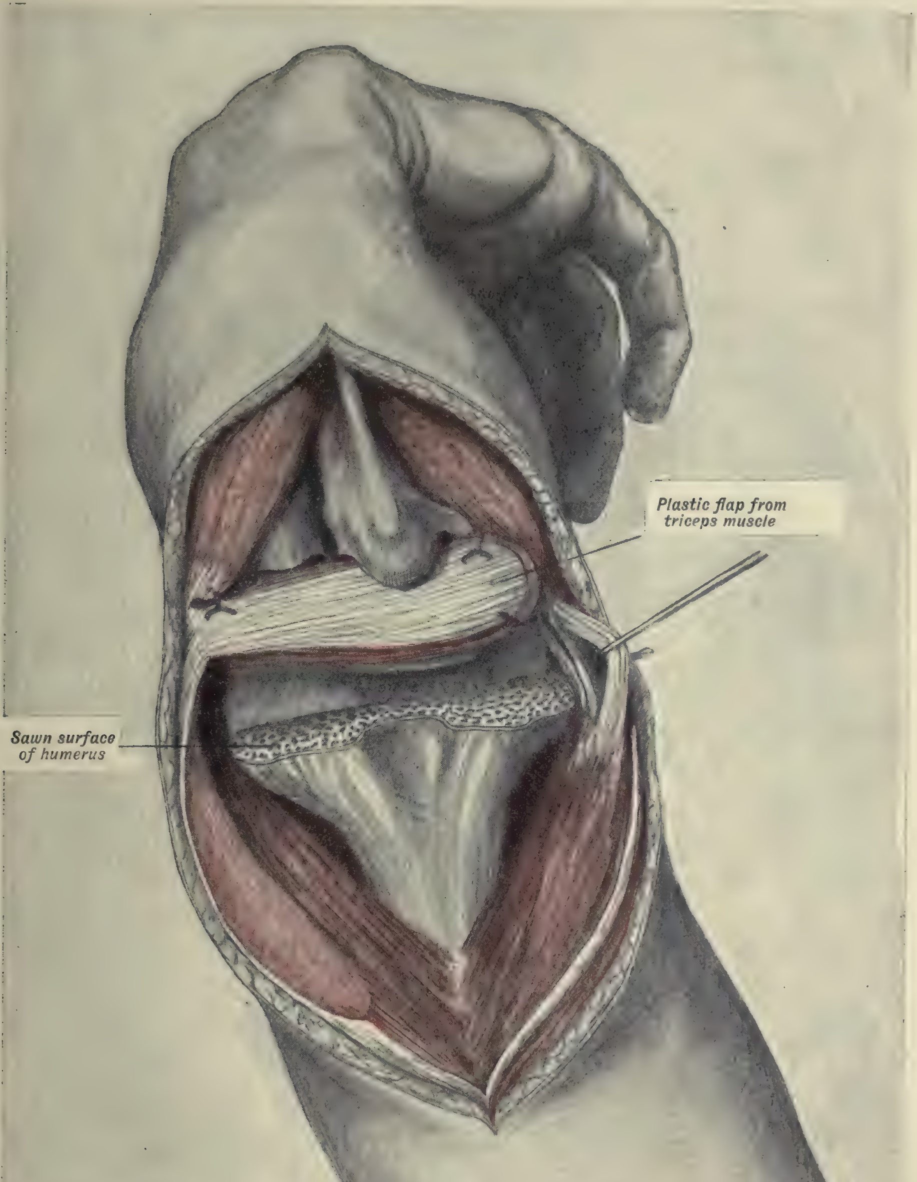

FIG. 57.—Excision of the elbow joint. Stage II. The entire articulation has been removed and curved saw-cuts made through the bone. A plastic muscle flap is taken from the half of the triceps opposite to the ulnar nerve (Helferich) and sutured between the excision surfaces.

supervenes. Extension, combined with pronation, is then the usual result we obtain and an utterly useless arm. This may be forestalled at the time of operation by lodging a muscular flap from the triceps between the bones. After doing this the surgeon can have been extra sparing with the resection of the bones and yet end up with a thoroughly movable joint and one that may be subjected to strain. The necessary technique is represented in Fig. 57. The triceps muscle has been already split down the middle ; cut out a flat muscle flap from the half opposite the ulnar nerve : this should contain a piece of the tendon, the pedicle of which should be at the level of the joint fissure. This is laid transversely across the sawn surfaces of the radius and ulna and is fixed to the surrounding tissues with several catgut sutures. Now fit the bones together and pull the soft tissues over from each side : approximate the two halves of the triceps with deep sutures and stitch up the wound in the skin. This artificial interposition of muscle tends to keep the bones apart. (It should not be attempted except under aseptic precautions. It is especially applicable for the excision of old-standing dislocations and for ankylosis of bone. Helferich was the author of the method.) Other tissues are available. Undue resection can be avoided and a movable joint secured by transplanting fresh fat between the sawn surfaces ; or we may use a graft from the fascia lata of the thigh.[1]

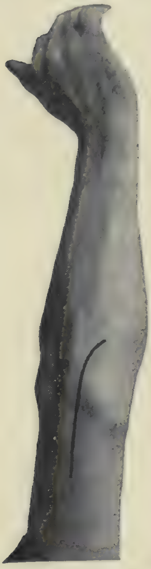

FIG. 58.—Kocher's incision for the excision of the elbow joint.

It is clear from our description of elbow excision methods that we prefer v. Langenbeck's method for practising on the dead subject. But Kocher's carefully planned incision (hook incision, Fig. 58) must not be underestimated on that account. It is especially advisable in cases where one can begin by cutting into the radio-humeral joint, and where the intention is to remove only the foci of disease and leave the internal lateral ligament quite intact. One great advantage of the method is that it aims specially at preserving the innervation of the muscles round the joint.

4. *Excision of the Knee Joint.*

It is best to consider excision of the knee joint along with that of the elbow. As in the elbow, so in the knee, three bones project into the joint—tibia, femur and patella. They do not of course correspond to the ones that enter into the elbow. Unlike the elbow, the knee is a hinge-joint pure and simple; it has no movement corresponding to pronation and supination. It follows, therefore, that the fibula is not coated over with articular cartilage and lies right outside the cavity of the joint. Two tuberosities (epicondyles) are palpable on the femur, an outer and an inner; the massive condyles are palpable behind these. The patella lies between the condyles and corresponds to the olecranon; it is firmly attached to the tubercule of the tibia by the ligamentum patellae. The joint fissure is the only thing difficult to palpate; in extension it corresponds to the lower edge of the patella. The fissure is bridged over by the tense lateral ligaments, which keep the condyles in close contact with the broad head of the tibia. The head of the fibula is also easily felt on the outer side.

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[1] The best results are obtained by basing the after-treatment on physiological principles, *i.e.* the osteoblastic cells must not be scattered among the soft tissues. The parts are kept immobile for three weeks, the first movements are gentle and the range of flexion is only gradually increased.—TR.

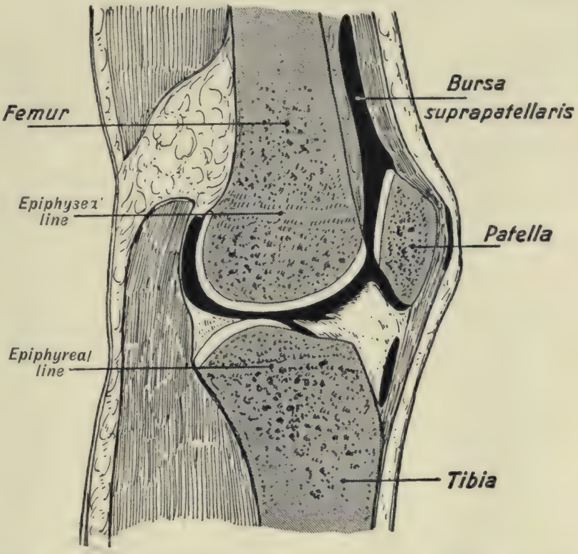

FIG. 59.—Sagittal section through the knee joint. For purposes of illustration the articular capsule has been enlarged a little way upwards.

These relations are diagrammatically represented in a sagittal section (Fig. 59), which indicates at once the position and the insertion of the articular capsule. The capsule is inserted all round the epiphysis in such a way that the epiphyseal line lies wholly outside the joint; it forms a large recess that reaches from below the patella right up under the common extensor tendon and disappears during flexion. Particular attention should be paid to this recess during excision. The crucial ligaments are two tense intra-articular structures that run from the tibia to the adjacent surfaces of the condyles. In the elbow joint there are no structures analogous either to them or to the two menisci or fibro-plates, whose function is to maintain the firm apposition of the articular surfaces.

Speaking generally, excision of the knee joint is the simplest excision of all, for it is easy to preserve the more important soft parts. All the important tendons and muscles lie on the flexor aspect, and the great nerves and vessels lie hidden in the popliteal space (compare the chapter on the ligature of the popliteal artery). The external popliteal nerve is the only one that has branched away from the main bundle; before ever reaching the popliteal space this nerve gradually slants towards the outer side and comes to lie close behind the head of the fibula. But it always lies so far to the flexor side as to make it easy for the surgeon to avoid it in an uncomplicated excision (cf. Fig. 137).

We take Textor's curved incision (Fig. 60) as the normal procedure in excision of the knee joint. Lateral incisions, internal (v. Langenbeck's) and external (Kocher's, Fig. 63) aim at maintaining the continuity of the extensor apparatus. But as they are more troublesome, we only employ them in cases where a partial excision is thought possible and we are still hoping for the retention of a movable joint. The transverse incision (Volkmann's, Fig. 61), which cuts across the patella, and the upper arched incision (Hahn's, Fig. 62), possess no real advantage over that of Textor; though occasionally the presence of fistulae may induce one to substitute some such alternative method.

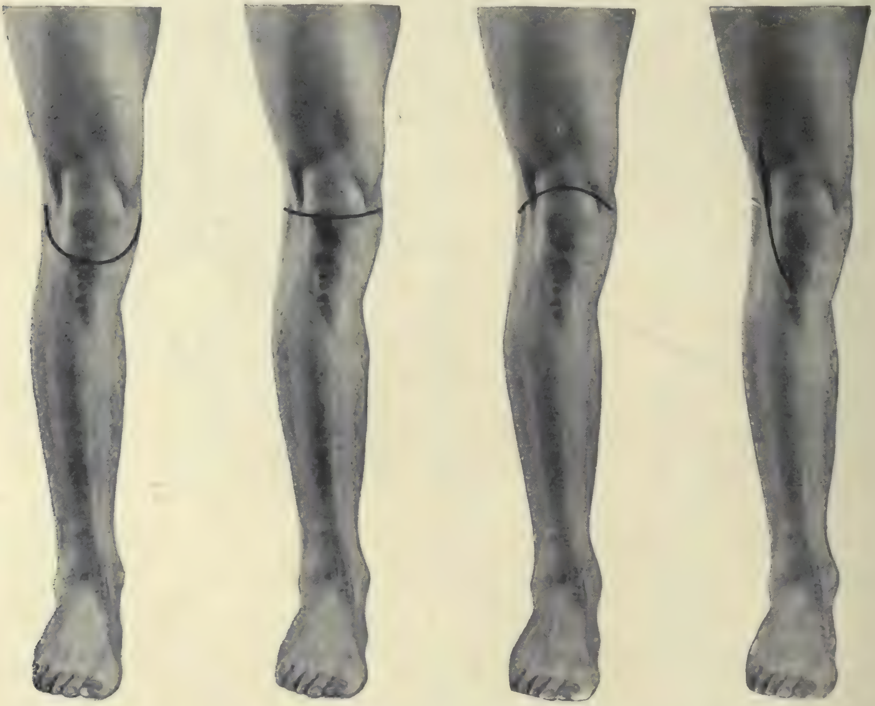

FIG. 60. FIG. 61. FIG. 62. FIG. 63.
Incisions in the resection of the knee joint.
Textor's. Volkmann's. Hahn's. Kocher's.

The patient lies on the dorsum. The knee joint is flexed to a right angle, with the sole of the foot on the table. The operator palpates the outlines above described and carries the first incision across from one epicondyle to the other in a great bow below the patella. One sweep with the knife brings him to bone, right through the ligamentum patella and into the joint. He now pulls the patella upwards with a sharp hook, gradually goes on flexing and divides the lateral ligaments on both sides; this is done as far back as possible and close to the circumference of the condyles. The knee fissure now gapes open and the tense crucial ligaments come into view; they are cut across close to the condyles, towards which the knife is to be directed. This frees the whole intercondylar notch, the tibia falls downwards, and we are able to survey the back of the capsule. This is the last of our accessory cuts, and the picture we now get is shown in Fig. 64. The insertion of retractors into the edge of the articular capsule enables us to see into the supracapsular recess.

Let us now describe the operation for complete excision. on the assumption that we are dealing with a widespread tuberculosis.

Begin by inserting several retractors into the skin at the upper edge of the wound and lift it from off the patella and the lateral fibres of the quadriceps extensor. Now make a fresh transverse cut above the patella right through the insertion of the quadriceps, but stopping short at the articular capsule of the supracapsular recess.

We now attend to the patella. Where total excision of the knee-cap is not required we saw off only the posterior surface, *i.e.* the surface that looks into the joint; its anterior surface is not exposed and its ligamentous connections are not divided. This enables us to retain the muscles antagonistic to the posterior flexors and prevents the leg from being gradually drawn into the flexed position later. We now draw the skin and quadriceps well up and make a clean dissection of the whole of the supracapsular recess (shown in Fig. 59) from off the muscle, dividing it at its insertion along the anterior condylar margin. The next step is to saw off the condyles. The femur is held firm by the assistants and the condyles are thrust well out of the wound. The operator uses a Butcher's saw with a narrow blade and saws off the cartilage and the superficial layers of the bone; the sawn surface should be curved convexly.

This curved resection surface is an idea of Helferich's; it is especially good in cases that are not too far advanced; in larger resections it is better to saw straight across and get two flat surfaces, to ensure the accurate coaptation of the bones. The surgeon next inserts a single-toothed retractor into the intercondylar notch and dissects away the remains of the lateral ligaments and capsule with knife and forceps, clears out the intercondylar notch and proceeds to the posterior part of the capsule. Laying the knife flat on the capsule he strips it clean, while the assistant keeps it tense by thrusting his closed fist into the popliteal space. Injury to the popliteal artery is unusual; it is the deepest vessel and lies nearest the capsule. The accident is only to be feared when the disease has broken through the back of the capsule, or when the artery has been displaced by those scar masses that

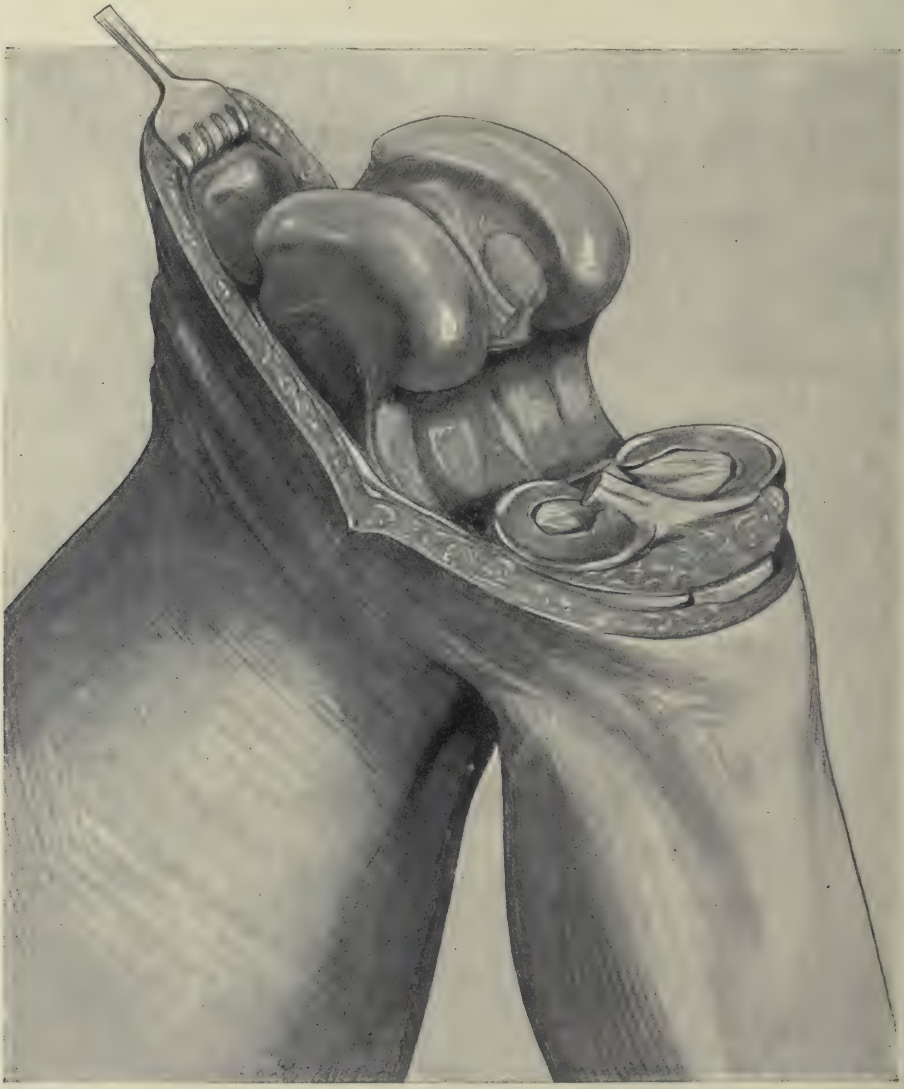

FIG. 64.—Excision of the knee. The joint has been opened by Textor's curved incision (Fig. 60). The lateral and crucial ligaments have been divided.

accompany angular contractions or ankyloses. Extra caution is desirable in those cases. On the other hand its branch, the azygos articular, is usually cut. This vessel runs to the capsule in the middle of the popliteal space.

The next step is to excise all round the head of the tibia, keeping the knife turned towards the bone, until finally the head of the bone projects into the wound on all sides. It is then sawn through, the sawn surface being made concave to correspond with that of the femur. The tibial insertion of the capsule, the menisci and the stumps of the crucial ligaments are removed along with this slice of bone. The operator now examines the two sawn surfaces and clears out any remaining foci of disease with sharp spoon or gouge. If he has sawn with a sure and confident hand the two surfaces should fit together. Above all, there should be no resultant valgus or varus malposition; if this be the case the saw must be reapplied to correct it. The operator must do his level best to leave the two epiphyseal lines intact; otherwise, at least in children, the bone grows in an abnormal direction and deformity is the result. The onset of later deformity is also to be feared if the structures which mediate extension are not replaced in their continuity. If we have to remove the patella therefore we should always try to leave the ligamentum patella with a long stump running down to the tubercule of the tibia. This must be sutured to the cut surface of the quadriceps prior to the closure of

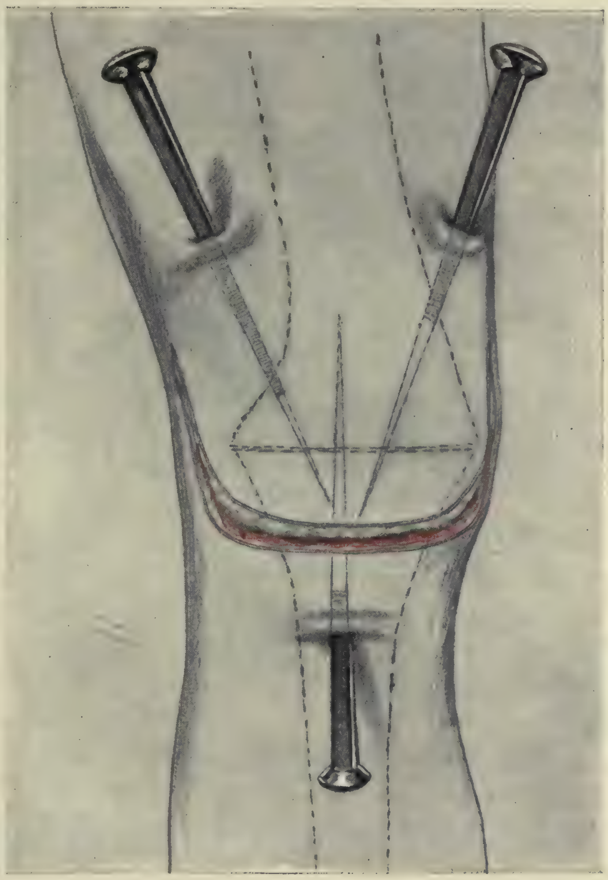

FIG. 65.—Nailing of the bones after excision (Hahn's method). The skin and subcutaneous tissue have not yet been stitched.

the wound. If this cannot be successfully accomplished, it is better to throw the antagonistic group out of action by severing the tendons of the biceps, semimembranosus and semitendinous muscles; this is done through the excision wound, due regard being paid to the external popliteal nerve.

The last step in the excision of the knee is to coapt the bones in extension. Use wire sutures or strong catgut. Strong needles can be forced directly through the bones in the case of children, in adults we bore holes and draw the sutures through them. As handy a way as any is to use nickelled nails (after Hahn), passing three good strong ones through the skin. They are driven in, as Fig. 65 shows, previous to the stitching of the extensor structures and skin. These nails give immediate and absolute rigidity. The bones should not be fixed in full extension but slightly in the flexed position; this helps the patient later in walking and in managing the rigid limb.

5. *Excision of the Shoulder Joint.*

The shoulder joint has the widest range of movement of any joint in the body. Its capsule is correspondingly wide all round and its socket very small in comparison with the articular cartilage of the head. The socket is part of the scapula: its circumference is enlarged by the glenoid ligament. The movable head would scarcely stay in such a flat socket and would be the subject of more frequent dislocation, were it not for the two strong bony projections of the scapula, the acromion and coracoid processes, and the coraco-acromial ligament connecting them. These form a roof over the socket and prevent the head from being forced too far upwards. The humeral head is covered by the deltoid muscle; its outlines cannot be accurately palpated except in individuals with underdeveloped muscles. Place the subject at the edge of the table with a pillow under the shoulder. Begin by palpating the clavicle, the coracoid process and the acromion. During the palpation flex the arm at the elbow and rotate the head of the humerus. The greater tuberosity is massive: the lesser tuberosity lies in front of it: the two tuberosities are continued down as two crests, with the bicipital groove between them. The long head of the biceps runs upwards in the groove to be inserted above the glenoid cavity. Rotate the arm till the greater tuberosity comes to lie below the middle of the coraco-acromical ligament and let an assistant keep it in this position. Another assistant holds himself ready with two retractors. The operator uses an excision knife. He begins the incision at the acromial end of the clavicle and continues it over the greater tuberosity, following first the anterior border and then the crest till it reaches the level of the anterior axillary fold (cp. Fig. 66). The cut is made through skin and fat. It is then deepened in its whole extent till it penetrates the coraco-acromial ligament and enters the joint beneath, splitting the fibres of the deltoid down as far as the surgical neck. Avoid splitting the muscle too deeply in a downward direction, as one wishes if possible to preserve the innervation to the anterior part of the muscle (circumflex nerve). Retract the muscle fibres on either side, and palpate the bicipital groove with the finger, getting the arm rotated so as to bring the groove into the wound. Next split the tendinous roof of the bicipital groove in a longitudinal direction, and lift up the tendon of the biceps in the whole length of the incision. Draw it forward with a blunt retractor and so conserve it during the remainder of the operation. The usual excision cuts are now to be made in a longitudinal direction: and according to the special indications they can either be made outside the capsule, or the back of the capsule may be exposed at once by subcapsular or subcortical methods. The limb should be forcibly rotated inwards by the assistant. This puts the soft parts on the stretch and the operator frees them one after another from their insertions into the greater tuberosity. Then rotate the arm outwards and do the same for the lesser tuberosity, keeping the long tendon of the biceps retracted well forwards out of the way. Excise the capsule round its insertion into the humerus. If you have been thorough with the excision cuts, the head now springs easily out of the socket. Now turn the knife towards the back of the bone and make circular sweeps, thus freeing the head and allowing the proper amount of bone to be sawn off. A chain or wire saw is best, and the saw-cut is made transversely. This stage of the operation is shown in Fig. 67.

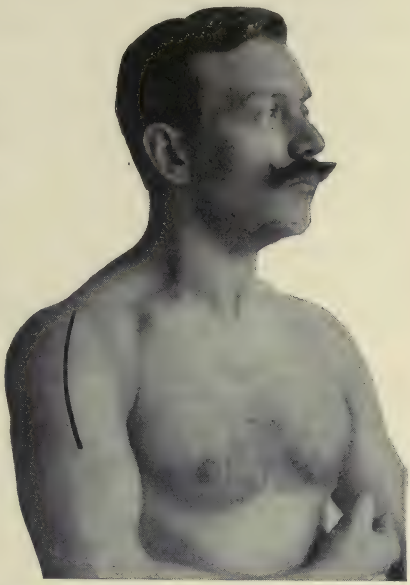
FIG. 66.—Incision for the resection of the shoulder joint.

The glenoid socket is now exposed. The wound is held wide open with retractors, and the operator removes all diseased parts of the capsule with knife and forceps and clears out all diseased foci from the socket with a gouge and sharp spoon. He finally replaces the bony stump in the fresh socket and the biceps tendon in its groove. According to the nature of the disease the wound may either be left open or a drainage tube inserted and the wound partially closed.

To meet special cases an incision can be chosen that keeps to the anterior border of the deltoid (Ollier's incision); this leads at once to the anterior articular structures. It is used, for instance, in partial excisions, in exposing the joint in recurrent dislocations with a view to shortening the capsule, or for arthrotomy in old standing dislocations. In addition to those given above we can recommend Kocher's method of total excision. It is thoroughly well planned, though a little complicated. Kocher attacks the joint by making a posterior curved incision. This crosses the spine of the

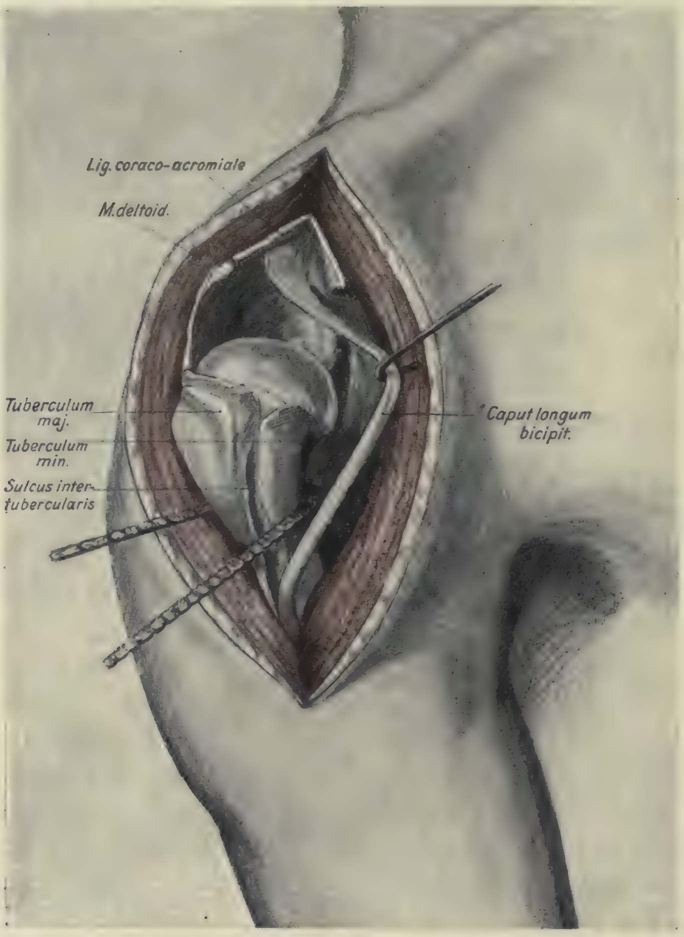

FIG. 67.—Excision of the shoulder joint. The skin incision has been made and the humerus freed by means of resection cuts; the surgical neck of the humerus should now be divided with the chain saw.

scapula, which is divided into two halves with a chisel. The acromial end of the bone is then pulled forwards over the shoulder joint together with all the soft tissues. One obtains a complete view of the opened joint and the innervation of the muscles is preserved intact.

The great nerves and vessels of the arm are far removed from danger in all such methods of excision. They lie in the axilla wrapt in a common bundle.

6. *Excision of the Hip.*

The technique in excision of the hip is much the same as for the excision of the shoulder but the operator has to face distinctly greater difficulties. The chief function of the hip joint is that of support: its ligaments are therefore much stronger, its mobility much less and it lies deep under the muscles. It is only in front that the tissues covering the head of the femur are comparatively thin, and it is impossible to enter from this side as the great vessels of the groin are in the way. The acetabulum and the cotyloid ligament form a hemisphere to the centre of which the femoral head is anchored by the ligamentum teres. The capsule is large and envelopes the greater part of the long femoral neck; it is reinforced by strong ligaments, especially the ilio-femoral ligament, which connects the blade of the ilium with the great trochanter. Corresponding to the two tuberosities of the humerus we have the great and small trochanters in the femur Only the great trochanter is palpable from the exterior: it thus forms the guide to the incision.

The incision is placed externally and runs parallel to the fibres of the gluteus maximus (*v.* Fig. 68). v. Langenbeck was the first to employ this method.

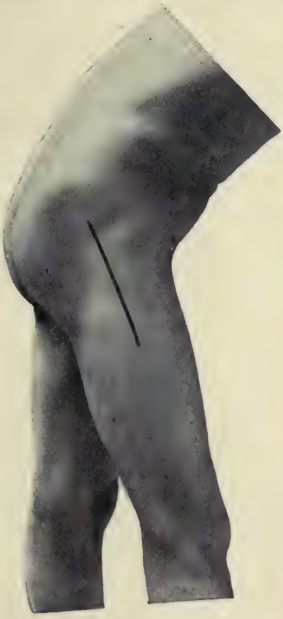

FIG. 68.—v. Langenbeck's incision for the resection of the hip joint.

Lay the subject on the sound side and slightly flex the hip. Palpate the great trochanter. Commence the incision midway between the posterior superior spine and the great trochanter and continue it over the middle of the trochanter and along the femur some four finger-breadths downwards. Use a strong excision knife and run the cut right on to the bone dividing the three supratrochanteric muscles, the gluteus maximus, medius and minimus; the ilio-femoral ligament is also divided and at this point the knife penetrates right into the joint. The services of two assistants are now required just as in excision of the shoulder. The one inserts large sharp retractors into the wound and draws the divided gluteals apart: the other flexes the knee and rotates the leg as far inwards as possible. The operator now proceeds with the typical resection cuts and clears all the soft tissues from off the great trochanter and the neck of the femur: this can only be managed bit by bit, as the wound goes very deep. The next step is to rotate the femur outwards and conduct a similar periosteal separation at the anterior aspect of the head and neck. Get the limb rotated now out now in as you require, and press ever deeper; open up the capsule still

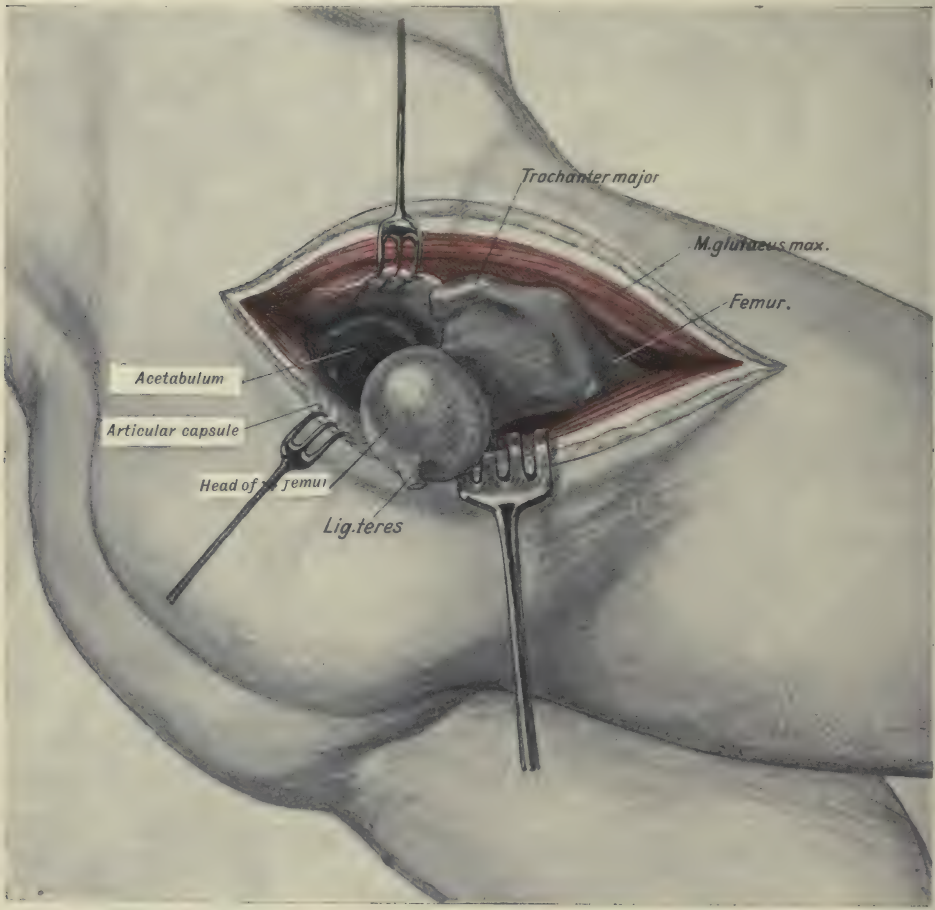

FIG. 69.—Excision of the hip. The femoral head has been luxated outwards; the socket can then be inspected.

further and lay bare and bring to view a considerable part of the femoral head. Then get the assistant to rotate the leg strongly inwards, introduce a knife between the head and the socket and sever the ligamentum teres; it is often possible to tear the ligament away by forcibly displacing the head. The head of the femur then springs out of the socket. Turn the knife towards the bone and make circular cuts so as to expose the neck of the femur as far down as the small trochanter; the ilio-psoas tendon is inserted here and should be left intact.

This stage of the operation is represented in Fig. 69. The diseased part of the head and possibly of the neck too is sawn off, a procedure quite analogous to that done in excision of the shoulder. Even the great trochanter has to be removed in cases where the disease is very far advanced. We now obtain a view of the whole joint; its different parts, capsule and socket, are now cleared thoroughly of every particle of diseased tissue. The after treatment of the wound is carried out as in the shoulder, except that it is left open more often, in order to prevent any retention of fluid.

Just as in the case of the shoulder there are a whole series of different methods for excising the hip. The Hüter-Schede incision penetrates at the outer edge of the sartorius muscle, between it and the tensor fasciae femoris; the anterior is the first part of the joint to be exposed. Kocher describes a posterior curved incision and lays stress on avoiding any unnecessary injury to muscles and nerves. We have always found v. Langenbeck's incision thoroughly satisfactory both for teaching and operative purposes. Reference should be made to Kocher's work for a more exact description of his method. The line of his skin incision is shown in Fig. 70. The method affords a splendid view of the joint.

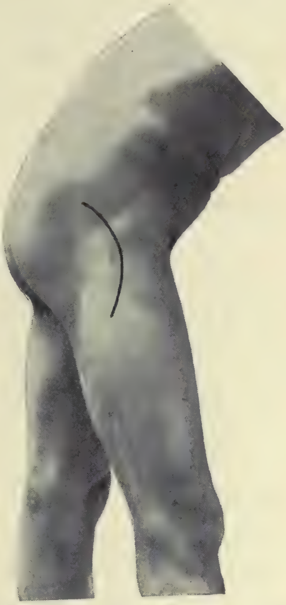

FIG. 70.—Kocher's incision for the resection of the hip joint.

SECTION III

AMPUTATIONS AND DISARTICULATIONS IN THE EXTREMITIES

INTRODUCTION.—REMOVAL OF EXTREMITIES IN GENERAL

THE amputation as well as the disarticulation of limbs is a much practised art. As it was of prime importance for injuries sustained in battle it became a leading chapter in all courses of operative instruction and was enriched by a great number of improvements in the matter of detail. These operations had formerly to be carried out without the help of narcosis or the Esmarch's bandage ; rapidity of execution was therefore all the rage and many special points of technique were elaborated. These are now out of date, so we are free to pay all the greater attention to the careful fashioning of the stump ; the improvements made along this line are well suited for practice on the dead body. Numerous conservative methods have been applied, particularly in cases of joint disease, and these have limited the indications for amputation. Thus in peace as well as in war the removal of an entire limb is much less often performed than it used to be.

We speak of AMPUTATION when a limb is severed in its bony continuity ; of DISARTICULATION when the removal is done in the line of the joint. Otherwise the procedure is essentially the same in both methods ; the soft tissues must be shaped in such a way that they overlie the sawn or disarticulated stump of bone so as to cover it completely. The primary formation of the stump is thus the principal point in the modern art of amputation. In most cases we suture up the wound completely and await primary union.

The simplest method of removing a limb is by Petit's original circular incision. It meets the really primary demand of every wound, *i.e.* it affords a completely smooth-cut surface. The proper treatment of the divided vessels and nerves will be described later. A smooth-cut surface is the most certain method and ensures rapid healing. The circular incision is carried out according to certain well-defined rules. Let us first take up the single circular incision.

Let us begin by noting the few instruments which are of special importance in amputations (together with those bone and tissue instruments already figured). They are represented in Figs. 71 to 76.

In all ordinary amputations the subject should be laid on its back. The condemned limb is propped up, or, in the case of the leg, pulled down over the lower end of the table. The operator requires two assistants. The first fixes the limb proximal to the site of amputation; the second grasps with his two hands the distal end to be removed. The operator stands between them, facing the seat of operation in such a way that the extremity of the limb comes away at his right hand. Placing his left hand above the intended line of amputation he carries a large amputation knife under the limb with its point turned upwards, applying it as shown in Fig. 79. Using the full blade of the knife he now divides all the soft parts with a uniform sweep right down to the bone: the knife is thus made to traverse the posterior girth of the limb (*v.* Fig. 78). Apply it a second time and divide the remaining soft tissues from above, keeping if possible

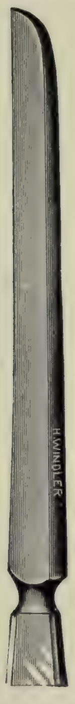

Fig. 71.—Amputation knife.

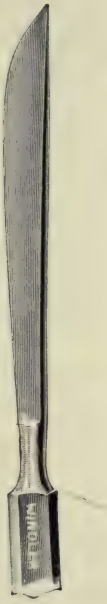

Fig. 72.—Knife for forming flaps.

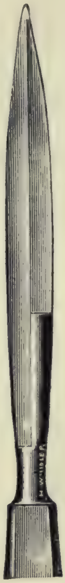

Fig. 73.—Amputation knife (for work between bones).

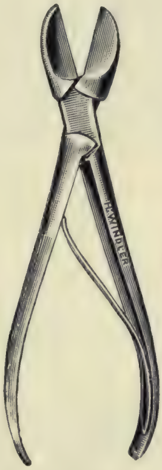

Fig. 74.—Liston's bone forceps.

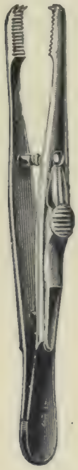

FIG. 75.—v. Bergmann's fixation forceps.

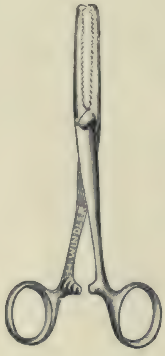

FIG. 76.—Kocher's artery forceps.

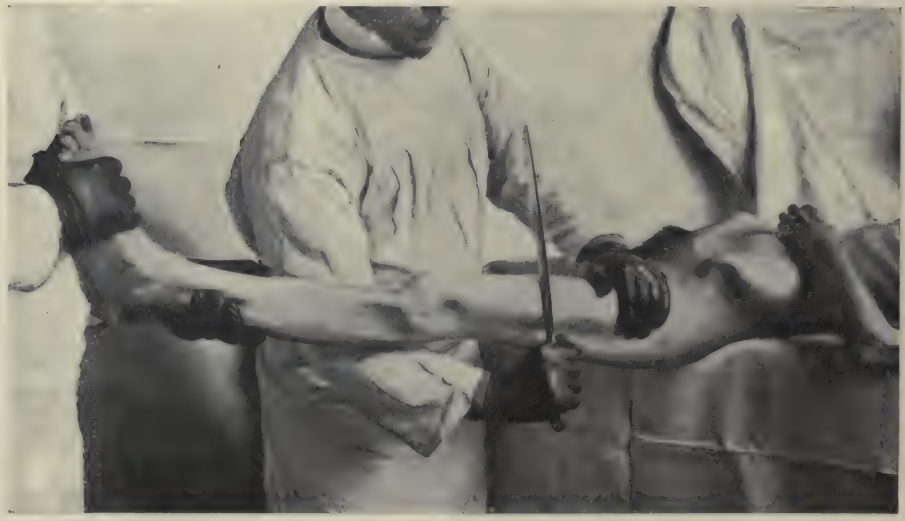

FIG. 77.—The amputation knife applied immediately prior to incision.

at the level of the first cut. This second incision is shown in Fig. 79. The bone is sawn across in the same plane as the soft tissues (*v.* Fig. 80). Before setting the saw to the bone one must always observe to strip the soft tissues and periosteum from the point of application, otherwise the soft tissues are lacerated and are left in a condition unfavourable to healing, and bits of tissue get caught in the teeth of the saw and render them blunt. A well-carried saw should run easily. The beginner presses it down and thereby only prevents its acting; it is the back sweep that should do most of the work. Apply the instrument, and begin by forming a groove in the bone with a few short sweeps. Then make use of the full blade and quicken the action. Finish with slow sweeps to prevent the rest of the bone breaking away. If there are two bones in the limb, it is the rule to divide both at the same time, provided you are aiming at a uniform stump. But when there are two bones, division of the soft parts is a more difficult business. The circular cut is carried out as described, but then the soft tissues between the bones require to be divided with a special knife and the knife has to be carried round each of the bones at the same level.

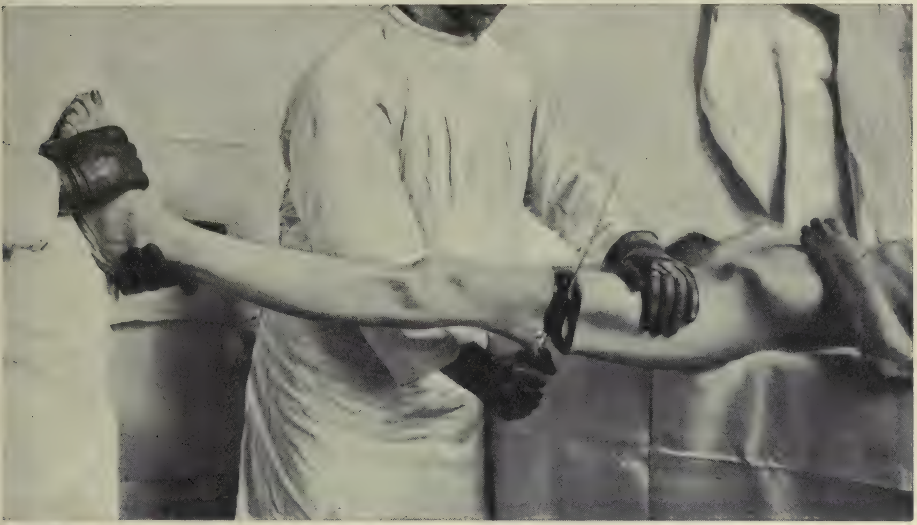

FIG. 78.—The single circular method. Stage I.

This single circular incision has been abandoned in its simplest form by the majority of surgeons—at least in all these cases where they aim at

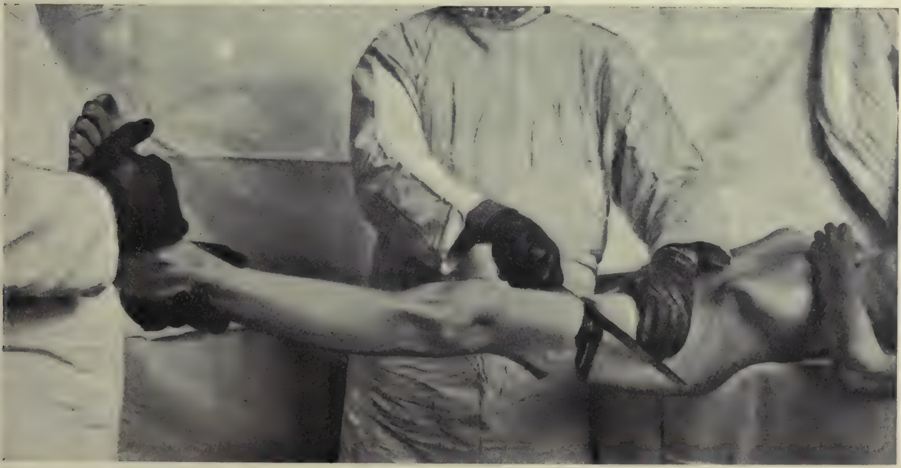

FIG. 79.—The single circular method. Stage II.

primary healing and the formation of a good stump. Observation of such a circular incision makes it at once evident that there will be a permanent deficiency in the soft tissues covering the bones. The most that can be expected is for a scar to form over the bones in the centre of the supporting surface; and even though it may be possible to approximate the soft tissues over the bone experience teaches that bony stumps tend to become ulcerated (*Ulcus prominens*), especially as they usually become more and more pointed from disuse atrophy (the so-called conical amputation stump). It was the

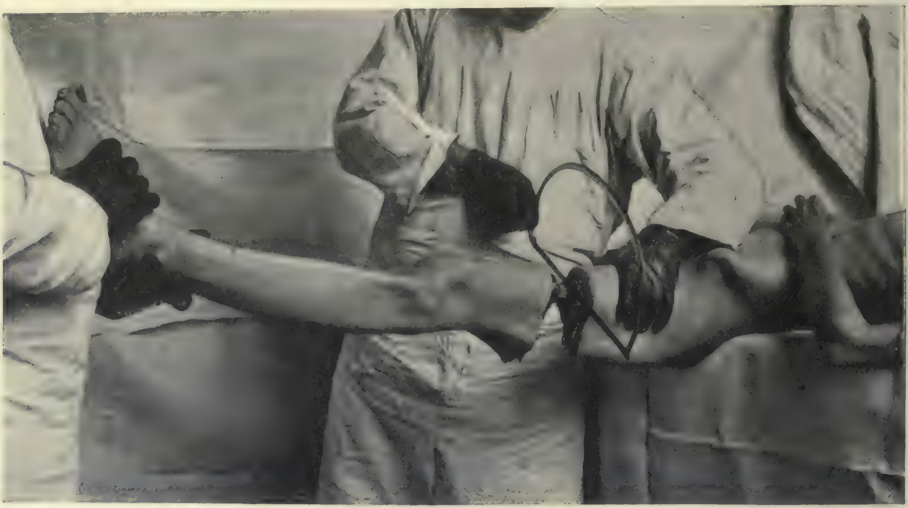

FIG. 80.—Single circular method of amputation. Sawing the bone.

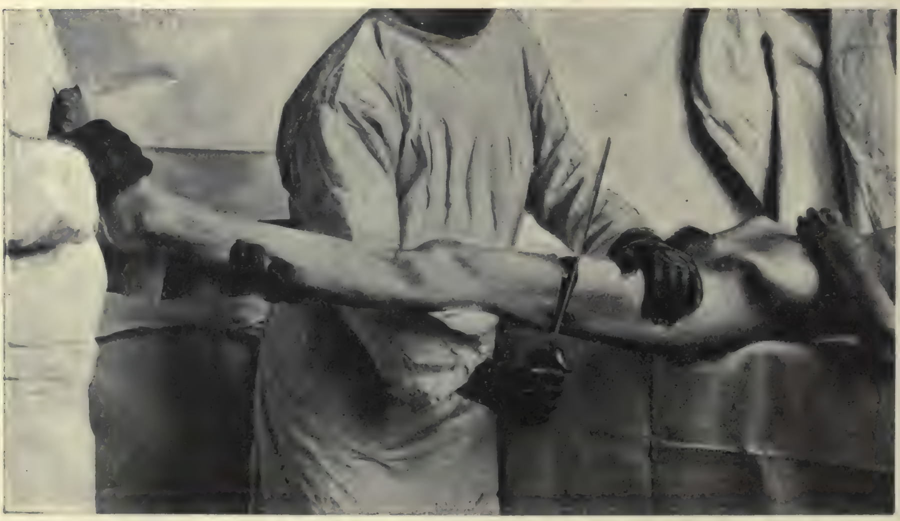

FIG. 81.—Double circular method. Stage I. (Division of skin and subcutaneous tissue only.)

appreciation of this that led to the application of the double circular and flap incisions, for these methods enabled the bone to be amputated at a higher level than the soft tissues. In this way it was possible to obtain a good covering of soft tissues and bring the scar into a more welcome position.

We therefore proceed to a description of the double circular incision. The idea of this is to cover the bony stump with a cuff of skin. Fig. 81 shows how the first cut divides only skin and fat, reaching merely to the deep fascia. Proceed to separate the layer of fat from the deep fascia and turn up a cuff of skin. Still holding the knife in the typical way, divide the remaining soft tissues and finally divide the bone at a considerably higher level. In most cases the turning up of the skin cuff is no easy matter and two lateral longitudinal cuts are therefore added in order to slit up the cuff. This procedure brings us to another method—the formation of anterior and posterior flaps. This is suitable for all amputations, and is correctly regarded as the principal one in vogue. We can also appreciate the advantage of being able to make the one flap (usually the anterior) bigger than the posterior: it prevents the resulting scar from running right over the supporting surface. Fig. 82 illustrates how the corners of the two flaps are rounded off; it also represents the technique of flap separation. The

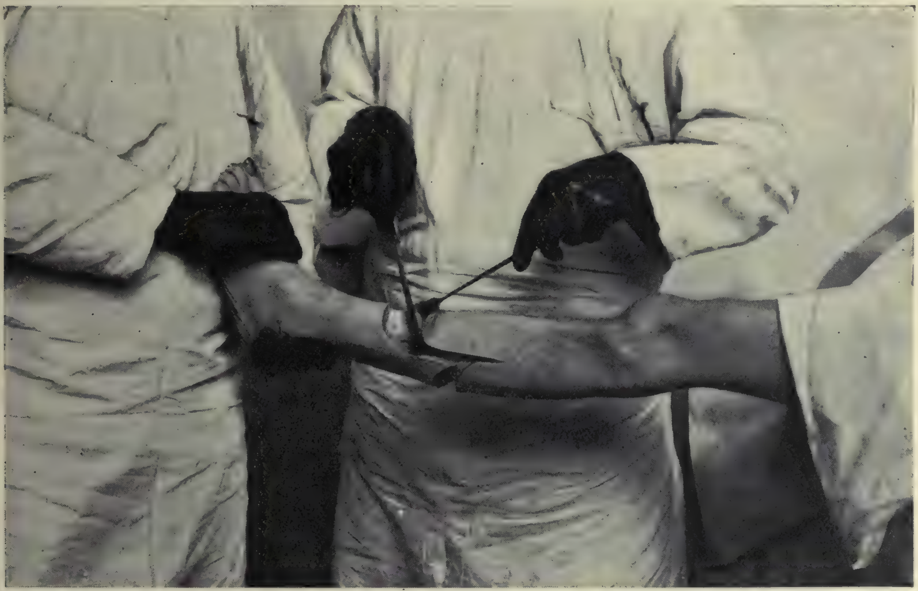

FIG. 82.—Amputation by anterior and posterior flaps. Manipulation of amputation knife in raising the flaps from the muscles.

vessels of the subcutaneous fat should never be injured; they guarantee the nutrition of the flaps. We therefore adhere closely to the fascia, directing the knife towards it and not towards the fat. A small, curved knife is used—the so-called amputation knife. Sometimes a rounded tongue-shaped flap is formed on the one side only, sufficient to cover the whole amputation surface. The flaps are thrown upwards and kept firmly retracted. The next step in the double circular or flap incision is to divide all the other soft tissues and the bone opposite the root of the flap, as shown in Fig. 83.

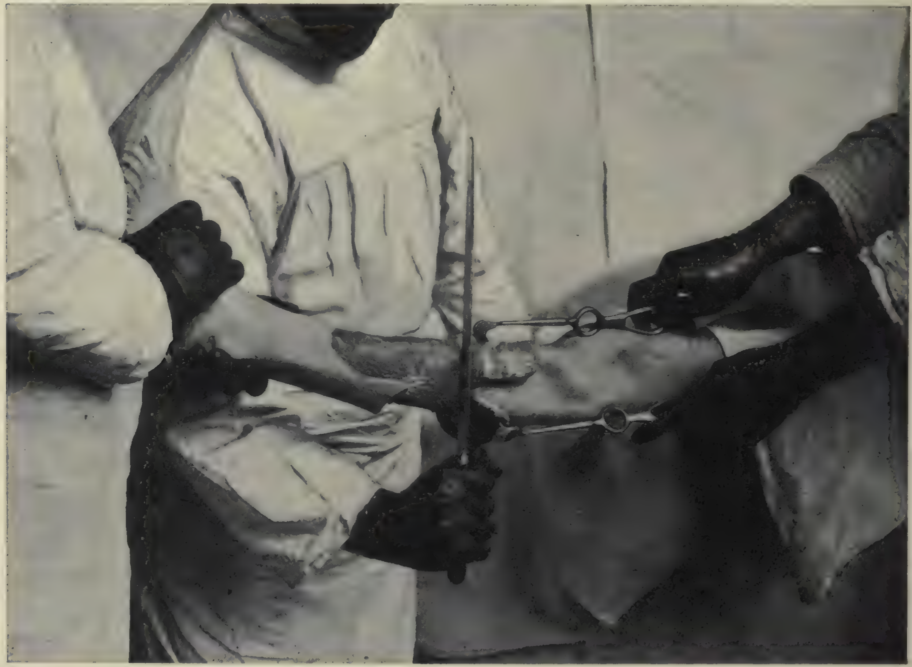

FIG. 83.—Amputation by flaps. Stage II. Dividing the muscles at the base of the flaps.

It is not the rule nowadays to fashion flaps containing the entire depth of muscle with a view to bolstering up the stump of bone. In particular, the old transfixation method is no longer practised, where voluminous soft flaps were fashioned by slanting the cut from within obliquely outwards. The double circular incision in general use enables one, as a rule, to coapt the muscles over the stump with a few sutures and to stitch them up—at least, this is true in the case of the thigh, where a good soft tissue padding is a special desideratum. The best way to manage this is by forcing up all the soft tissues with pieces of gauze before ever the saw is applied; in this way the stump of bone can be made as short as one likes. Of course one must not run away with the idea that such a pad of muscle will remain uniformly thick. It naturally atrophies almost completely, and all the more since it is deprived of part of its function. But suturing the muscles across in this way has the effect of preventing any excessive retraction of the soft parts. It should therefore be carried out wherever possible. The subperiosteal method of Bruns must be referred to, as it is a good way of forming the skin muscle flap. It has many adherents. Make a single circular incision first of all and saw through the bone ; then make two longitudinal cuts through the soft tissues right down to bone and strip up all the soft tissues along with the periosteum. The muscles are retracted apart like the two wings of a door, and it is then easy to divide the bone once more at a higher level and to approximate and suture the soft parts over it.

A special form of flap formation is effected by the racquet incision. This is chiefly used for disarticulating fingers and will be taken up in that connection.

In all methods of flap formation we must regard it as an absolute rule never on any account to cut the flaps too short. One is very apt to do so on commencing the practice of amputation. A unilateral flap should always be longer than the diameter of the limb, and the soft parts must allow of stitching without tension.

We ought not to leave the general question of amputations without some reference to the treatment of the various tissues, *e.g.* the blood vessels, the nerves, and in particular the bones. The smooth-cut surface of the circular incision affords one a good opportunity of becoming acquainted with the transverse section of the limb in question and the anatomical relations of the different structures. The large arteries are lying in their respective connective tissue septa ; they are to be clamped with pressure forceps and ligatured. Treat the veins in the same way. The next step is to search for the smaller blood vessels, but this can scarcely be practised on the dead subject. The main nerve trunks, however, are found in their anatomical positions ; they are to be drawn out and divided as high up as possible in order that the amputation neuroma which arises at their ends may not become implicated in the scar of the stump.

The treatment of the bony stump is of the utmost importance for after function. Bier's work has shown us that a useful stump is the goal to be aimed for. Since then the amputation stump has had to meet quite a new requirement, namely, that it should support the whole of the body weight ("supporting stump"). We used formerly to be satisfied with concealing the stump in a support but did not venture to expose it to any particular pressure; it was the proximal bony processes that were allowed to carry most of the weight of the body: *e.g.* the tibial tuberosities or even the pelvic girdle. Surgeons often took the line of least resistance and amputated at the seat of election, *i.e.* not far below the knee joint, then flexed the stump and allowed the tibial tubercule (which is used to pressure) to bear the weight. This became the primary rule in amputations through the diaphysis; the broader epiphyseal stumps and more especially the disarticulation stumps were seldom deemed capable of supporting the direct weight of the body. Pirogoff's osteoplastic stump was found to be the best for withstanding the direct weight (*v.* Figs. 102 to 106). Bier was the first to demand that the medullary canal of the diaphysis should be closed, in order to preclude the painful bony excrescences produced by both the marrow and the periosteum. He accordingly published his osteoplastic method for treating the stump of the bone (Figs. 109 and 110). He also maintained that the stump should be subjected early to the weight of the body. Pirogoff's amputation has served as a basis for the work of other surgeons (Gritti's osteoplastic amputation, Figs. 111 and 112, Sabanejeff's operation, Figs. 113 and 114, and others).

Hirsch's method betokened another great advance. He taught that exercises should be cautiously commenced on the stump as soon as the wound had healed. This was to accustom it to pressure and weight, and more especially to prevent the occurrence of atrophy, the stump in short taking on the qualities of an epiphysis. Hirsch made the further demand that surgeons should give up the earlier methods and especially should stop stripping up the periosteum; he ascribed the occurrence of painful bony excrescences to bits of the periosteum being left behind. Then Bunge followed up this aperiosteal method and made yet another step forward; after fashioning his bony stump, he stripped off the periosteum and scraped the marrow out with a spoon. Wilm's managed to cover the sawn surface with a broad tendon (quadriceps at the knee, tendo Achillis at the ankle), and got good results and a movable scar (tendinoplastic method). So nowadays there are quite a number of methods which meet Bier's demand for a diaphyseal stump that will bear the direct weight of the body.

In Bier's clinic we employ osteoplastic methods for preference. But in cases where they are contraindicated we usually divide the periosteum a little above the line of the saw-cut and scrape out the marrow. Whenever we can manage it we approximate the muscles over the bony stump and begin exercises at the earliest possible moment, according to Hirsch's direction. Our attitude towards the former teaching is very important; we consider the old dogma of the uselessness of disarticulation stumps as nothing short of a complete error. Asepsis has set us on a coign of vantage and we no longer see any danger in opening the joints. The ends of disarticulation stumps have been rounded off by nature and they are not subject to an excess of callus formation. It is impossible to appraise them too highly (especially at the knee). Early exercises in a padded support are necessary even in their case, but they are soon capable of bearing the direct weight of the body. We must therefore give up the prejudice entertained against them, especially as it is always easier with them to carry out the requisite technique and arrest the attendant bleeding than in the case of sawn stumps.

Blood-sparing methods were all along the standard in operation technique. They are therefore due a brief reference, though they cannot be practised on the dead subject. It was v. Esmarch who introduced bandaging for blood-saving purposes and this great advance has done away with all the flurry that once characterized the course of amputations; we can now do a quiet operation and one that will be of benefit to the patient. Manual compression of the main arterial stems serves for the same purpose, *e.g.* in the groin during removal of the leg; or we can do a preliminary exposure and ligation according to the rules given in Part I. High amputations, more especially those of the shoulder and hip, have been deprived of their chief danger and can be carried out without loss of blood, since Trendelenburg introduced his improved method of blood-sparing (an ordinary high spica followed by the application of an Esmarch's bandage). Momburg's devascularisation of the lower half of the body denotes a further step in the same direction; it is the application, under definite precautions, of an Esmarch's bandage round the waist.[1] Finally, we may add that even without the help of bloodless methods the operator need never hesitate to perform an amputation, provided as he goes along he immediately ligatures every vessel that his knife encounters (Extirpation method).

A. AMPUTATIONS AND DISARTICULATIONS IN THE UPPER EXTREMITY.

1. *Removal of the Fingers.*

In removing diseased and crushed fingers the governing principle is to economize tissue. We have often to cover the bony stump with any material available. In practice therefore the question of a typical operation frequently does not arise at all. Indeed, in order to retain a bit of the finger defects in the soft parts are made up by flaps taken from other parts of the body; these may be either attached or free. The provision of a satisfactory padding for the bony stump is absolutely essential in the case of the fingers, for a painful adherent scar at the end of a finger can render the entire hand useless. The best method to practise on the dead subject is the semicircular dorsal incision followed by an oval palmar flap. The latter is thrown over the dorsum of the stump and fixed in that position: the line of suture lies on the dorsum away from the grasping surface. The method can be understood from Figs. 84 and 85.

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[1] Macewen controls the aorta by direct compression. An assistant stands on a stool at the left side of the table, and presses his right fist down into the abdomen immediately to the left of the umbilicus. He brings his full weight to bear by crossing the right foot in front of the left. This position can be maintained for quite a time.—TR.

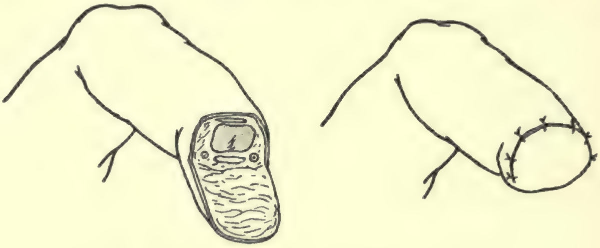

FIG. 84. FIG. 85.

Disarticulation of a phalanx by means of a palmar flap.

We follow conservative principles and remove only as much of the bone as is required for the formation of the stump; bone forceps are used for dividing the bone. The best finger stumps are got by disarticulation. If we are to incise from the dorsum straight into a joint the position of the joint fissure must be remembered. The projecting knuckle always belongs to the proximal bone. When one wishes to expose a joint the fingers should be flexed, and the line of the joint will be found to correspond to the arrows in Fig. 86. A cross section of the finger contains the extensor tendon on the dorsum and two flexor tendons on the palmar aspect: the digital arteries overlie the latter on either side.

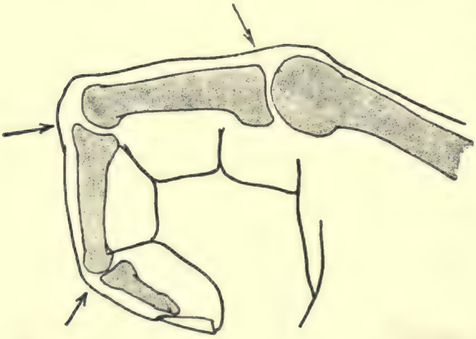

FIG. 86.—Diagram showing the situation of the finger joints.

If the finger is to be removed at the metacarpo-phalangeal joint the racquet incision is used: it was referred to above (*v.* Fig. 87). An assistant holds the adjoining fingers apart and a semicircular incision is made on the palmar surface in the flexor crease: its ends meet in a short longitudinal incision on the dorsum of the hand. Carry the cut right down to bone. Then proceed to open the joint, preferably from the side. Divide the capsule all round and the finger falls off. The head of the metacarpus lies in the wound; it may be removed with a metacarpal saw or heavy bone forceps: this brings the adjoining bones closer together and the gap is not so noticeable. The two severed arteries are also seen in the wound and are to be ligatured. Cut the three tendons off short and let them retract out of sight.

Disarticulation of a finger together with its metacarpal is an operation that requires special practice. It can be performed in the cases of the thumb and 5th fingers. Fig. 87 shows how the racquet incision is prolonged up in the cases of the thumb and little finger as far as the bases of the metacarpals. An assistant retracts the edges of the wound. Rotating the finger as he goes the operator tries to shell the whole bone out of the periosteum, at any rate he keeps close to the bone; he thus avoids injury to neighbouring structures. In the thumb the joint is reached between 1st metacarpal and trapezium, in the little finger the joint between 5th metacarpal and unciform; he then proceeds to disarticulate. The edges of the racquet incision are easily approximated and form a scar that lies on the dorsum and is out of the way.

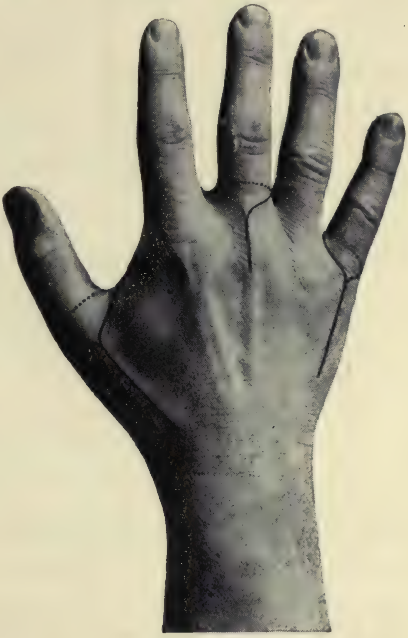

FIG. 87.—Disarticulation of the fingers by the racquet incision (in the 1st and 5th fingers for disarticulation of the metacarpal bone as well).

Incisions common to several fingers are often practised when more than one finger is to be disarticulated. But the incisions are usually quite atypical, the flaps being fashioned to suit the special requirements of each case.

2. *Disarticulation at the Wrist.*

This operation is also an easy one. Typical disarticulation of the hand is carried out between the radius and ulna on the one side and the bones of the carpus on the other. The position of the joint is to be made out by palpating the styloid processes of the radius and ulna and plotting a curved line between them slightly convex towards the forearm. The capsule is a loose one, to correspond with the great mobility of the wrist joint: it extends from the broad lower epiphysis of the radius to the scaphoid, lunar and cuneiform bones of the proximal carpal row. Both circular and flap methods are possible, but the double circular method is the best. The skin incision is made at least a thumb's-breadth below the carpo-metacarpal fissure. The skin is easily lifted, especially if two lateral incisions are added (Fig. 88*a*). The single dorsal flap is equally good, or a flap starting from where the ball of the thumb meets the dorsal surface. The skin flaps are retracted upwards. The operator grasps the hand about to be disarticulated with his own left hand and divides the extensor tendons and the articular capsule with an even cut; the joint can then be forced open by means of palmar flexion. Division of the lateral ligaments and the soft tissues of the palm completes a simple operation. The projecting tendons are cut short and the stump is left with nothing but a covering of skin. The positions of the radial and ulnar arteries are already well known from their ligatures at the wrist (*v.* Fig. 26): they are easily found, the ulnar artery accompanied by the ulnar nerve. The median nerve lies on the flexor side in the middle of the soft tissues (cf. Fig. 133). If you are unable to stitch the skin fully over the stump with an entire absence of tension, the projecting styloid processes of the radius and ulna may be sawn off.

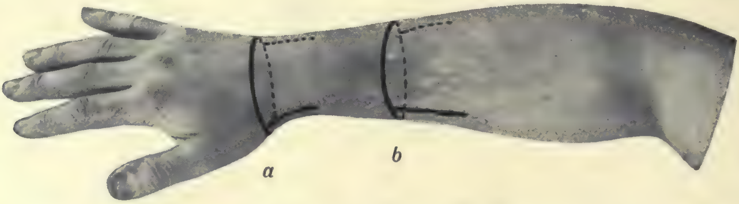

FIG. 88.—(*a*) Circular incision for disarticulation at the wrist; (*b*) incision for amputation of the forearm.

3. *Amputation of the Forearm.*

Abduct the arm of the subject. One assistant fixes the upper arm, another fixes the wrist. The operator forms two skin flaps, equal in length to the short diameter at the seat of amputation (*v.* Fig. 88*b*). The arm should be held up during the fashioning of the flaps, but after that it is to be extended horizontally and supinated; the amputation, and especially the sawing of the bones, is to be completed with the arm in this position, so that the two bones may be made of equal length. But first of all carry an even circular cut through all the soft tissues, dividing the interosseous parts at the same level and using the knife shown in Fig. 73. The cut is made most evenly when the arm is kept steadily supinated and extended. The cut surface offers a rather complicated picture (cp. Fig. 89). It represents the right forearm held in supination. In the amputation surface radius and ulna appear in cross section; the posterior interosseous nerve is seen among the dorsal muscles in the upper third of the arm; the two main arteries, radial and ulnar, are visible on the flexor side: they lie on each side of the flexors to the fingers and are accompanied by the radial and ulnar nerves. The third nerve is the median; it is the largest, and lies in the middle of the flexor aspect between the superficial and deep flexors. Attention should also be paid to the small anterior interosseous artery (cp. Fig. 26 for the course of the main arteries).

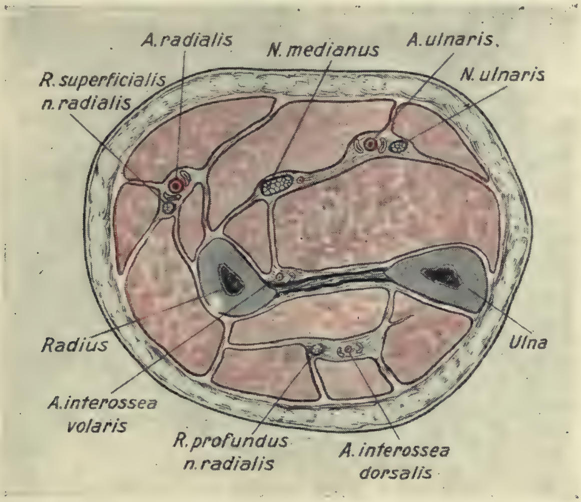

FIG. 89.—Cross section of the right forearm in supination (about the junction of the upper and middle thirds).

4. *Disarticulation at the Elbow.*

We have already indicated in the introduction that removal of parts of the upper extremity should always be done sparingly; every particle of tissue is valuable and may become invaluable for consolidating the part and for the management of an artificial limb. It is this consideration that prevents us making a more extended use of disarticulation at the elbow. You obtain a fine rounded-off stump, and the bucket of the artificial limb secures a firm grip on the projecting epicondyles. Nevertheless, a high amputation of the forearm is always preferable; for if it is possible to retain even a short stump of the forearm, containing the insertion of the biceps (radial tuberosity) and the insertion of the triceps (olecranon process), the artificial limb becomes movable—an incalculable gain.

If disarticulation is necessary there is the choice of numerous methods, by both circular and flap incisions. It is advisable to palpate the epicondyles and starting from them to form two oval flaps, one from the flexor, the other from the extensor side, as shown in Fig. 90*a*. In fashioning these flaps the beginner is very apt to forget about the elastic contraction of the soft tissues and to cut the flaps too small. Free the flaps and retract them upwards. The operator now takes his stand in front of the fully extended and supinated arm, and divides all the soft tissues on the flexor aspect. This cut is made transversely and goes right down to bone, entering the elbow joint a finger-breadth below the interepicondylar line As soon as the fissure of the joint comes into view, the capsule on the flexor side is to be completely divided, together with the strong lateral ligaments. The joint surfaces now fall apart. Draw the dorsal flap well up and divide all the extensor structures close to the olecranon from within outwards. In the cross section our eye is caught by the three stout nerves; the main arterial stem has already divided into radial and ulnar, and the median nerve lies near it (cp. Fig. 26).

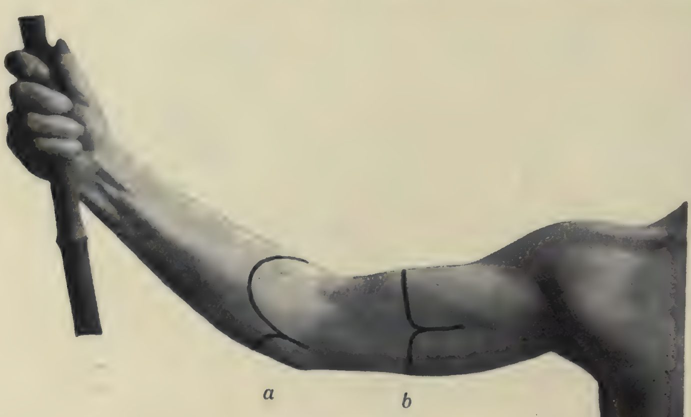

FIG. 90.—Incisions (*a*) for disarticulation at the elbow; (*b*) for amputation of the upper arm.

It is often recommended to form a strong flap of skin and muscle from the flexor side to act as a padding for the disarticulation stump. But in cases where we have such an excess of tissue at our disposal we should never think of disarticulating, but perform the high amputation at the elbow as above described.

5. *Amputation of the Upper Arm.*

This is perhaps the simplest of all operations. Even the old simple circular cut, inartistic as it was, could be employed with good results. If only care is taken after complete division of the soft tissues to draw them strongly up with pieces of gauze and saw the bone at a higher level, it will be easy to coapt and suture first the muscles, and then the skin, over the end of the bone. It is better, however, to employ the usual methods and to form two flaps of skin and fat (*v.* Fig. 90*b*), dividing the muscles and the bone at their bases. The cross section is shown diagrammatically in Fig. 91. It holds good only for the middle of the upper arm. The biceps and brachialis anticus constitute the flexor group of muscles ; the three heads of the triceps form the extensor group We noted under "Vessel Ligations" the connective tissue septum corresponding to the internal bicipital furrow : it is found on the inner side and forms a guide to the brachial artery and its venae comites. The median nerve lies immediately on the artery. The ulnar nerve is also in relation to the internal bicipital furrow, lying in close proximity to the triceps muscle. On the outside of the bone and in contact with it we find the musculo-spiral, an important nerve : it takes a spiral course round the humerus and is here far removed from the main bundle of vessels and nerves (cp. also Fig. 24 for the anatomy of the internal bicipital furrow).

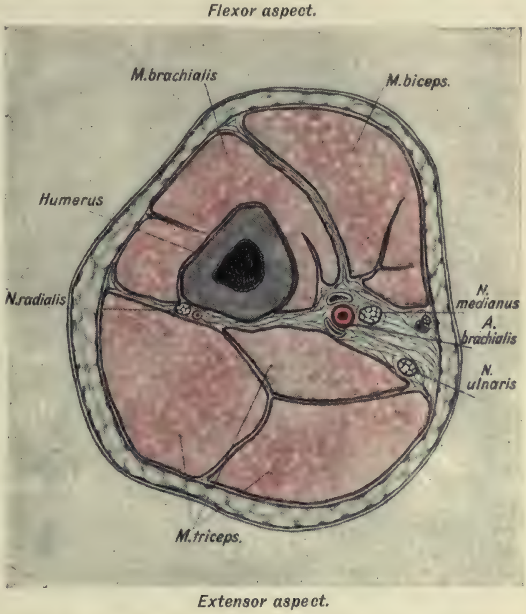

FIG. 91.—Cross section of the right upper arm.

6. *Disarticulation at the Shoulder.*

There is a wide choice of methods for the removal of the arm at the shoulder. Our choice depends primarily upon the extent of soft tissues that are available for covering the wound.

The usual operation is the so-called amputation-resection method. The disarticulation is done in two stages: a high amputation by a single flap, followed by the disarticulation of the head of the humerus from the glenoid cavity. This conservative and bloodless operation should be employed wherever possible (incision in Fig. 92).

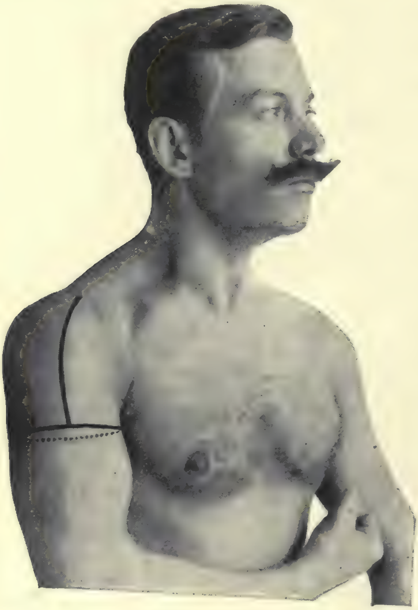

FIG. 92.—Incision for disarticulation at the shoulder joint (Amputation-resection method).

Lay the subject on the dorsum. Draw the affected shoulder over the side of the table, and abduct the arm at right angles to the body. Make a single circular incision well up the arm to correspond roughly with the insertion of the deltoid, and perform an even amputation through the upper arm: the bone is divided on the same plane as the muscles. Attend next to the cross section: ligature the large axillary vessels; draw out and divide the nerve stems, which are easily found; attend to any other vessels in the cross section. Remove the elastic bandage from the shoulder. Then carry a linear incision to meet the transverse one (Fig. 92); it corresponds exactly to Langenbeck's incision for excising the shoulder, described above. The next step is represented in Fig. 93, where the circular incision and the linear cut running to meet it are both well seen. The operator grasps the stump of the humerus with lion forceps, the soft tissues are retracted, the bone rotated to and fro and the tissues detached on all sides. Finally, the humeral head is excised from the socket, as in a typical excision. The operator should keep extra close to the bone posteriorly, thus preserving the posterior circumflex artery intact. Particular care should be taken not to injure the circumflex nerve, which innervates the deltoid: this muscle is of value for moving the stump and the artificial limb. After the bone has been removed there is no difficulty in uniting the soft tissues to form a muscular stump.

No other muscle-flap incision can compare with this bloodless method. One other incision, however, requires mention and is shown in Fig. 94.

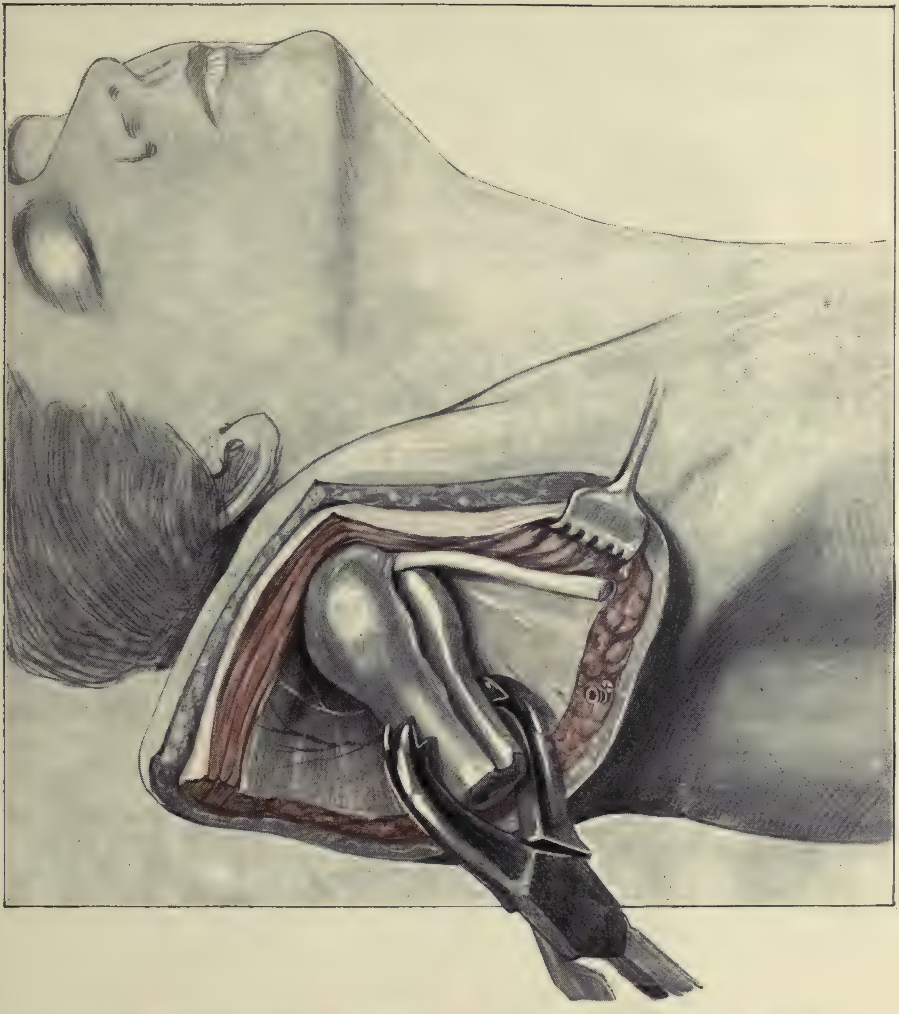

FIG. 93.—Disarticulation at the shoulder joint by the Amputation-resection method.

An epaulette-shaped flap is formed of skin and deltoid. On raising the flap from the bone, the shoulder joint is exposed and the humeral head disarticulated outwards. The arm is left hanging from the soft tissues and blood vessels of the axilla. An assistant compresses the flap in the axilla or controls the subclavian artery at the clavicle, and the operation is completed by dividing the axillary tissues from within outwards. Catch up the axillary vessels at once. If all the tissues surrounding the shoulder are condemned the extirpation is done by means of a short racquet incision (*v.* Fig. 95). Esmarch's bandage is not used. Starting near the coracoid process, the racquet incision is carried through skin and fat and then in an obliquely slanting direction through the layers of the deltoid muscle and into the joint. The larger vessels are ligatured each in turn. Always approach the axillary vessels and nerves from the front, so as to come on the structures in their anatomical sequence. After completing the operation it is well to round off the stump by sawing away the acromion and a piece of the acromial end of the clavicle. The skin-flaps are none too large and this manœuvre helps us to suture them over the glenoid.

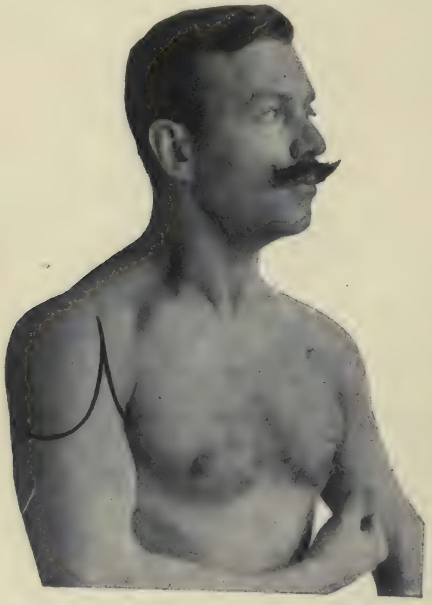

FIG. 94.—Incision for disarticulation at the shoulder joint (Epaulette incision).

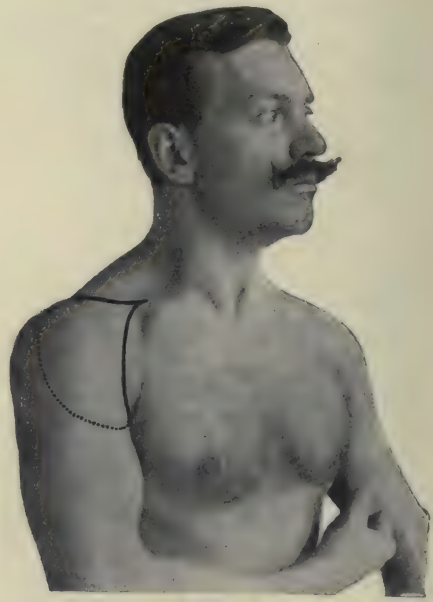

FIG. 95.—Incision for disarticulation at the shoulder joint (Racquet incision).

B. AMPUTATIONS AND DISARTICULATIONS IN THE LOWER EXTREMITY.

1. *Removal of the Toes.*

Our methods are more radical in the toes than in the fingers. We are not content with amputating the phalanges but always disarticulate them. The cutaneous scar is always made to lie on the dorsum; it follows that the flaps are taken from the flexor side. The technique is identical with that in the fingers; and we follow the same method in disarticulating at the metatarso-phalangeal joints as was described for the upper extremity. The procedure is illustrated in Fig. 96; it is the operation most often performed on the toes. In the foot one has to consider the functional rather than the cosmetic result. It is well, therefore, after exposing the head of the metatarsal in the disarticulation wound to let it remain in situ; for all the five metatarsal heads are important as functional supports of the foot.

Just as in the case of the hand, the question of disarticulating a toe together with its metatarsal is sometimes raised. It is done as follows:—

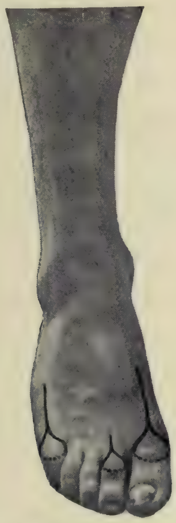

FIG. 96.—Racquet incisions for disarticulation of the toes. (In the 1st and 5th toes for disarticulation of the metatarsal bones as well.)

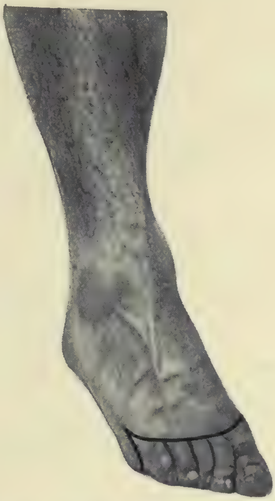

FIG. 97.—Incision for amputation at the metatarsus.

Prolong up the linear part of racquet incision (*v.* Fig. 96), retract the soft tissues and strip them off the bone, rotating the toe as you proceed; divide the capsule transversely and disarticulate the metatarsal bone from the bone it rests against, either cuneiform or cuboid. An even dorsal scar is the result, and the soft parts come together so naturally along the racquet incision that scarcely any sutures are needed. The tendons must always be cut off short and the arteries ligatured.

The surgeon will occasionally have to consider the disarticulation of some or all of the toes by means of a common plantar flap. If the skin is deficient, the heads of the metatarsals should be nipped off with large gouge forceps. Of course one only does this when it is absolutely necessary; never rob the foot of these important points of support without good cause.

When accurate coaptation of the plantar flap cannot be effected without tension we have to think of performing the regular amputation through the middle of the metatarsus. As shown in Fig. 97, a plantar flap is formed from all the soft tissues of the sole; the dorsal flap is quite short. Clear the end of each metatarsal bone in turn with a thin-bladed knife, and then saw them through. The flap is thrown upwards, thus ensuring that the scar will not interfere with walking. Ligature the digital arteries.

2. *Lisfranc's Disarticulation.*

The following series of operations (the amputations and disarticulations of Lisfranc, Chopart, Malgaigne, Pirogoff, etc.) are all concerned with the one problem, how to remove the metatarsals along with the toes and fashion a functionally useful stump on the most conservative principles. Although we have a wide range of choice, certainly the best and most useful stump is that of Pirogoff. The more conservative methods (of Lisfranc and Chopart) find it necessary to take a large flap of skin from the sole, a condition not often available in practice. Indeed it does not always pay one to be too conservative in the case of the foot; for short movable stumps, especially Chopart's, are apt to become pointed, from the preponderating pull of the tendo Achillis after the anterior antagonistic muscles have lost their insertions. Still, it is of great value to practise all these methods in order to learn the anatomical relations.

Fig. 98 gives a view of the bones of the foot. The sites of *a* (Lisfranc's) and *b* (Chopart's) disarticulation are drawn in with red lines. The tarsus consists of seven bones. The astragalus and calcaneus are the two largest, the former resting obliquely on the latter. The anterior convex surface of the astragalus articulates with the scaphoid bone; the three cuneiform bones are in their turn in relation to the scaphoid, the middle one being shorter than the other two. All three cuneiform bones carry a metatarsal bone. The anterior surface of the calcaneus is rather more concave and articulates with the cuboid bone; the cuboid, again, has two articular facets, with which the 4th and 5th metatarsals articulate.

Two points can be plainly felt projecting at the inner and outer edge of the foot. They enable us to establish the skeletal relations and to locate the joint fissures correctly. The scaphoid tubercule is on the inside over the arch of the foot; the hooked tubercule of the 5th metatarsal projects beyond the outer edge of the foot. Both points are seen in Fig. 98, and they will be referred to in the descriptions of the two following disarticulations.

Lisfranc's disarticulation commences with a palpation of the two tubercules. Lisfranc's line starts at the outer side of the foot immediately behind the tubercule of the 5th metatarsal and ends on the inside two fingerbreadths in front of the scaphoid tubercule. Mark off the two terminal points with stab wounds and join them with a skin incision: the flap has a slightly anterior curve (*v.* Fig. 99). Lateral linear incisions are carried from the two terminal points down to bone; they reach anteriorly as far as the metatarso-phalangeal joints of the 1st and 5th toes. Retract the short dorsal flap and deepen the dorsal transverse cut as far as the bone, thus dividing all the tendons. Penetrate Lisfranc's joint behind the tubercule of the 5th metatarsal, using a strong pointed knife and flexing the anterior part of the foot so as to let the joint fissure gape. Follow the oblique line of the joint, opposite the 5th, 4th and 3rd metatarsals. It must now be noted that the 2nd metatarsal juts up a little, as its corresponding cuneiform is shorter. A double bayonet bend is now made in the cut and the inner terminal point is reached between the 1st metatarsal and the internal cuneiform. Flex strongly and divide what remains of the articular capsules. Then slant the knife from within outwards and fashion a thick plantar flap from the soft tissues underneath the bones: this contains all the muscles and vessels and reaches as far forward as the balls of the toes; on reaching this point cut outwards and the amputated toes and metatarsals will fall away. Ligature the dorsalis pedis and the plantar arteries. The plantar flap can then be thrown up and sutured on the dorsum.

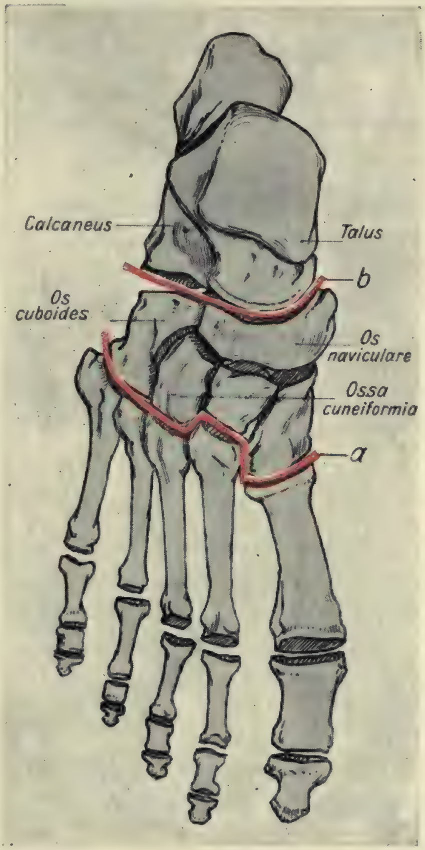

FIG. 98.—Diagram of the bones of the right foot. Lisfranc's joint shown by the red line *a*. Chopart's joint by the red line *b*.

Should the internal cuneiform project unduly and interfere with the suture of the wound, it should be sawn off. This rounds off the stump.[1]

In performing the operation on the left foot a right-handed surgeon should begin opening Lisfranc's joint from the inside, *i.e.* between the internal cuneiform and the 1st metatarsal.

3. *Chopart's Disarticulation.*

To understand this operation the introduction to Lisfranc's disarticulation should be read and reference made to Fig. 98.

We can plot the line of Chopart's joint by marking its two terminal points by means of stab wounds. Their sites are: on the outer side a thumb's-breadth behind the tubercule on the 5th metatarsal, and on the inner side a point just behind the scaphoid tubercule. Connect up the two points with a curved incision so as to form a dorsal flap (Fig. 100); then add the lateral cuts which reach forward to the roots of the toes. Penetrate into the S-shaped joint just as in Lisfranc's operation, by dividing all the extensor tendons and strongly flexing the foot. Note that the strong inferior calcaneo-scaphoid ligament is divided in the process, which allows the joint to spring open. The formation of a plantar flap and the treatment of the wound is carried out exactly as in Lisfranc's operation. The anterior surfaces of astragalus and calcaneus are exposed in the wound.

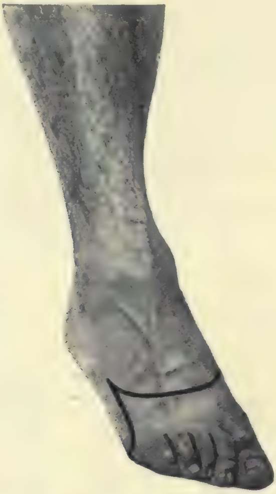

FIG. 99.—Incision for disarticulation at Lisfranc's joint.

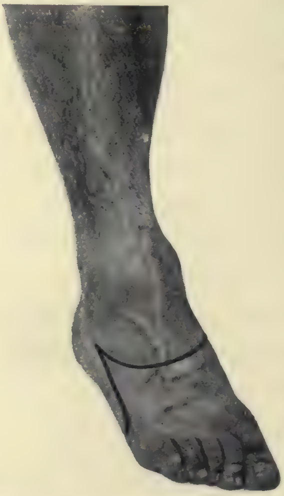

FIG. 100.—Incision for disarticulation at Chopart's joint.

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[1] This sawing of the internal cuneiform is sometimes termed Hey's operation.—TR.

The chief point in all disarticulations of the foot is to strike the line of the joint exactly. The patient and careful operator can be recognized at once: he divides the articular capsule without using any force and his knife remains sharp to the end. The impatient one misses the line of the joint, tries to overcome bony obstacles by force and notches his knife all to no purpose. It is well for the beginner to place the bones of the foot alongside the foot on which he proposes to operate.

In performing Chopart's operation on the left foot a not uncommon mistake is to penetrate the joint in front of the scaphoid bone instead of behind it. The operator does not usually become aware of the fact till his knife is stopped by impinging on the cuboid bone.

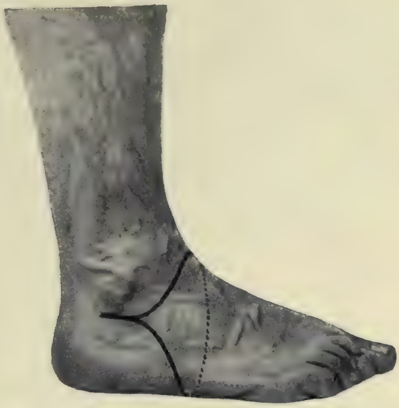

FIG. 101.—Racquet incision for Malgaigne's disarticulation.

4. *Malgaigne's Disarticulation.*

This operation is seldom indicated. All the bones of the foot are removed, with the exception of the astragalus. Disarticulation is effected between talus and calcaneus. The soft tissues of the heel cover the stump. The diagram of the racquet incision is shown in Fig. 101. It begins a little behind the tip of the external malleolus and is carried only skin deep at first. The cut crosses the inside of the foot just behind the scaphoid tubercule: it thus corresponds to Chopart's joint. Penetrate now into Chopart's joint with an excision knife, expose the head of the astragalus and sever its connections with the calcaneus below and at the sides. The calcaneus is now gradually shelled out; the foot must be rotated to and fro at the same time, and the cap of soft tissues strongly retracted. The calcaneus comes away with the rest of the foot. Keep close to the bone as you shell it out. Finally, cover the astragalus with the soft tissues of the heel.

5. *Syme's Disarticulation.*

We now come to Syme's disarticulation of the foot with removal of the malleoli. The method presupposes a sound and durable heel flap and is not often employed in practice. An incision is often made across the dorsum of the foot from the tip of the one malleolus to the tip of the other, and a stirrup incision is carried through the soft tissues of the sole. Strong plantar flexion is then exercised and we penetrate the ankle joint from the front: the articular ligaments are freed and the ankle joint opened up completely. We then pull the foot well downwards and free the calcaneus from the heel cap, keeping the knife ever directed towards the bone and avoiding any useless cutting into the soft tissues. The two arteries (dorsalis pedis and posterior tibial) are ligatured, and the malleoli sawn off, in order to secure a supporting stump. The heel cap is then replaced, a drainage tube introduced and the skin sutured.

6. *Pirogoff's Amputation.*

Wherever possible the osteoplastic amputation of Pirogoff's should be substituted for Syme's operation; it is an excellent method.

The aim of the operation is to divide both bones of the leg above the ankle joint, sawing through the calcaneus at the same time, and then allow the tuberosity of the calcaneus to heal up to the sawn surface of tibia and fibula. We secure a club-shaped stump, and one that is eminently suited for the attachment of an artificial limb. Its capacity for bearing weight is excellent, because the bony stump is finished off as in nature and the supporting surface is formed of skin that is used to pressure. The stump is therefore painless.

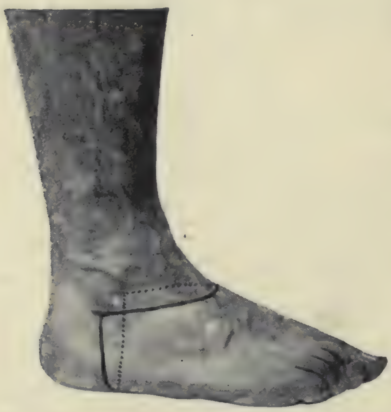

FIG. 102.—Incision for Pirogoff's amputation.

Pirogoff's amputation is carried out as follows:—The subject lies on the back, and the operator faces the sole of the foot; he grasps the end of the foot firmly with the left hand and carries out the two incisions with a medium sized strong amputation knife (cp. Fig. 102). Each incision begins and ends at the tips of the malleoli. The first is a stirrup cut that divides all the soft tissues down to bone at one sweep: it connects the tips of the malleoli under the sole of the foot. The second is an anterior flap incision connecting the malleoli and running at right angles to the first. The operator flexes the foot firmly and an assistant retracts up the dorsal skin flap along with the ends of the tendons. The capsule of the ankle is then divided and the knife thrust into the joint. The foot is extended and the

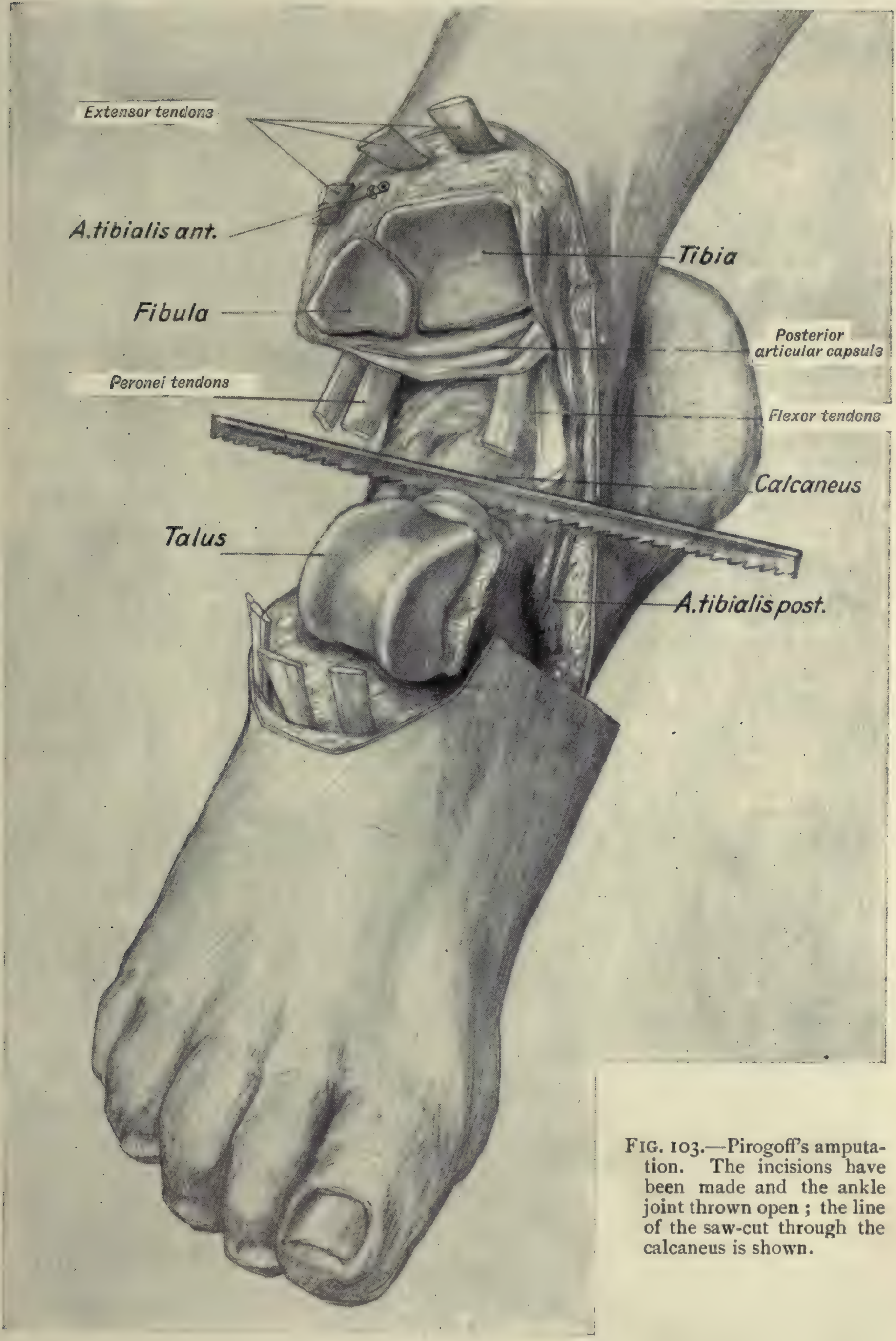

FIG. 103.—Pirogoff's amputation. The incisions have been made and the ankle joint thrown open; the line of the saw-cut through the calcaneus is shown.

lateral ligaments connecting malleoli to tarsus are divided. Avoid any needless division of the soft parts, especially on the inside, so as not to injure the posterior tibial artery. Reach back to the posterior ligament of the ankle and divide it at its insertion into the astragalus ; the knife then comes in contact with the calcaneus behind the trochlea tali. Still holding the foot in the left hand, the operator takes up the Butcher's saw in the right : it should be lying handy. As shown in Fig. 103 he places it on the calcaneus immediately behind the astragaloid articular surface, and saws it through exactly in the line of the stirrup incision. This completes the removal of the foot. The operator again faces the stump, grasps the heel flap of skin and bone and draws it backwards. Let an assistant retract up the dorsal flap once more, and by means of circular cuts expose both bones of the leg to just above the line of the ankle joint. Saw them across at this level. This separation is to be conducted with the utmost care so as to avoid injury to the posterior tibial artery, which is the only vessel supplying the flap. Determine whether it is possible to throw up the heel flap without tension, and see that the sawn surfaces (of leg and astragalus) fit accurately together. It is often found impossible to effect this without undue tension : tenotomy of the tendo Achillis will then be necessary. In anticipation of this it is often wise to begin the operation with a typical subcutaneous tenotomy of the tendo Achillis : the special description of this

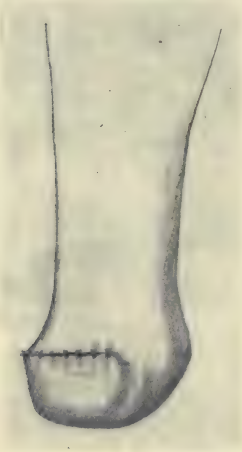

FIG. 104.—Appearance of the stump after Pirogoff's amputation.

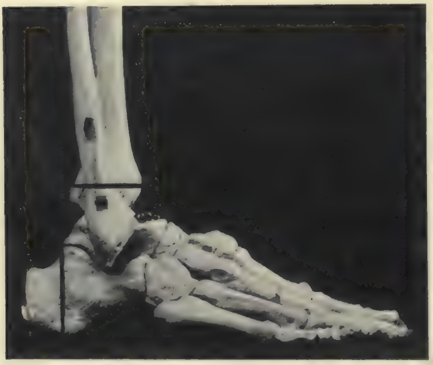

FIG. 105.—The lines for sawing the bones in Pirogoff's original amputation.

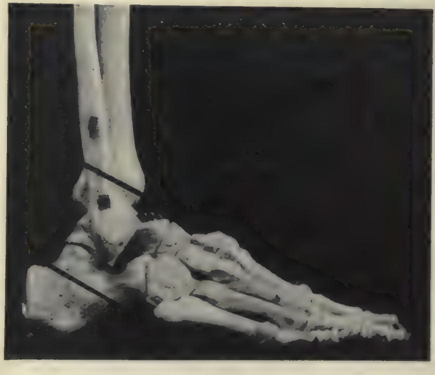

FIG. 106.—The lines for sawing the bones in the modified Pirogoff (Lefort, Günther).

is found in Part IV. The next step is to ligature the arteries on the cut surfaces: we already know the course of the anterior and posterior tibial arteries from the chapter on "Vessel Ligation" (*v.* Fig. 17); the former is divided in the dorsal flap and is found anteriorly between the tendons (*v.* Fig. 103); the latter is represented by the internal plantar artery and is divided in the stirrup incision: it is easily found on the inner side close to the sawn surface of the calcaneus. Fix the osteoplastic flap to the periosteum of the tibia and fibula with a few deep sutures, and finish off by stitching the skin. The resulting stump is shown in Fig. 104.

If along with this stump we consider the diagram of the bones (Fig. 105), it will be noticed that the approximation of two bony surfaces standing at right angles to one another leads to an undue twisting of the flap. The patient is forced to walk not upon the skin of the sole but upon the tender skin at the back of the heel. This may give rise after some operations to grave disturbances of function, and therefore numerous modifications have been devised; these are particularly associated with the names of Lefort and Günther. We adhere to Pirogoff's original method in Bier's clinic, but Fig. 106 shows how the matter can be remedied without any alteration in the preceding technique: the saw-cuts are parallel but are made to pass obliquely through the bone.

7. *Amputation of the Leg.*

Amputatio cruris is a frequent and important operation. We alluded above to the various difficulties that arise in rendering a stump capable of bearing weight; they apply to the amputation of the thigh but still more to the amputation of the leg, and many new methods have resulted from the work done in this field. The simplest way is to avoid the difficulties altogether by adopting the method known as amputation of the leg "at the seat of election." The leg is amputated a little below the knee joint; the knee is then flexed and the weight of the patient is allowed to fall upon the tibial tubercule as was nature's intention. This is a splendid method even yet, but it is only employed when amputation at this high level is really indicated. If it is possible to preserve more of the leg and the amputation is made at or below the middle, we possess sufficiently reliable methods to secure a stump that will bear the direct weight of the body even on extension. Of course the same remark applies to the leg amputated at the seat of election, it forms a most efficient support, even in the position of extension. A stump that is movable at the knee is always preferable as regards elasticity of gait to one that has been disarticulated at the knee joint (provided the tendinous insertions into tibia and fibula have been retained); in fact, we have to face the same conditions that we noted in disarticulation of the elbow. The short stump, flexed at the knee, is particularly suitable when healing is prevented by suppuration and bad scar tissue remains adherent to the bone. The rule that the scar should not be placed on the weight-bearing surface applies especially in the case of the leg: it should certainly never lie over the sawn surface of the tibia. The amputation is a simple one. Begin with an anterior flap incision, and add a smaller posterior flap (cp. Fig. 107*a*). Loosen and retract up the flaps of skin and fat. Then divide all the remaining soft tissues including those lying between the bones: do this in the usual way: the cut surface should be an even one. Before the bones are sawn through, the periosteum should be divided as far as possible and pulled down in the form of a cuff. This frees the projecting part of the bone from periosteum. We thus practise Bunge's aperiosteal method at this stage, and we also scrape out the marrow with a spoon. The bones are now divided, the fibula being sawn through a little higher than the tibia. If now the anterior flap be laid over the end of the tibia, it will be noticed that the anterior edge of the bone is too sharp to form a good end for the stump and the skin is insufficiently padded at this point. Accordingly we always make it a rule to round off all the edges, but especially the anterior one, with bone forceps or saw.

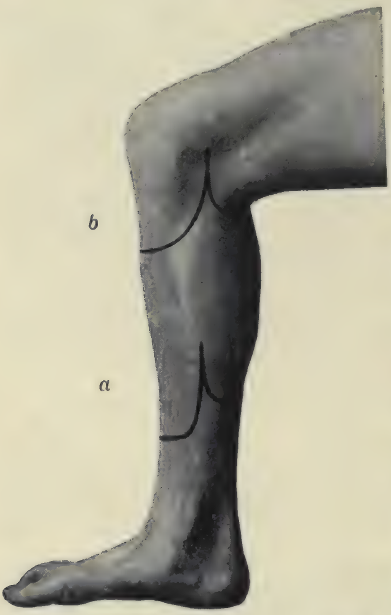

FIG. 107.—Incisions (*a*) for the amputation of the leg by anterior and posterior flaps; (*b*) for disarticulation at the knee.

It is important to understand the cross section of the leg, as shown in Fig. 108. The tibia is triangular in outline: its anterior and inner surface lies immediately under the skin. The fibula is surrounded by muscles, and is connected to the tibia by the interosseous ligament. The anterior tibial artery lies on the ligament between the tibialis anticus and extensor digitorum muscles. The peronei muscles overlap the fibula. The tibialis posticus and flexor digitorum muscles lie behind the interosseous ligament, with the posterior tibial artery behind them both. The thick muscles of the calf consist of the gastrocnemius and soleus. Note the position of the peroneal artery behind the fibula.

Bier's osteoplastic amputation of the leg is an imitation of Pirogoff's operation. It is carried out as follows: Form a large tongue-shaped anterior flap, using a knife of medium size: the apex of the flap lies on the surface of the tibia. As shown in Fig. 109 the flap is lifted up as far as the site of amputation, care being taken to preserve the periosteum covering the tibia. Now make two linear incisions in the periosteum at the anterior and inner borders of the tibia. Incise the periosteum across at the lower angle of the wound; raise it a little way in the form of a flap, and apply the saw at the base of the flap (cp. Fig. 109). Fix the narrow blade slantwise in the frame, thus enabling the saw to run parallel to the surface of the bone. A fine plate of bone is then sawn off, levered up with an elevator and turned right back (compare the inset in Fig. 109). Separate up the periosteum still further, thus providing it with a pedicle which though freely movable will afford sufficient nourishment to the flap. The entire limb is now removed along the red line as indicated; a circular incision is first made, the tissues between the bones are divided, and finally both bones are sawn through evenly and at the same level and their edges rounded off. Attend to the vessels and nerves in the cross section (Fig. 108). If the bony flap is now

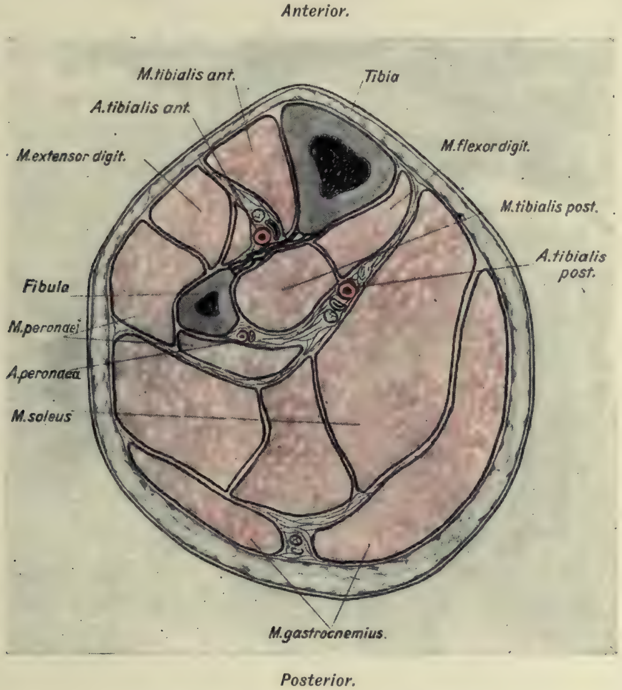

FIG. 108.—Cross section of the right leg.

reflected over the sawn surface of the tibia, it will cover both tibia and fibula. It is fixed in this position by passing a few sutures through the distal flap of the periosteum (Fig. 110). Finally, cover in the sawn surface with the large skin flap. The scar lies at the back of the leg. Bier's stump is an excellent one, and soon becomes capable of bearing the direct weight of the body.

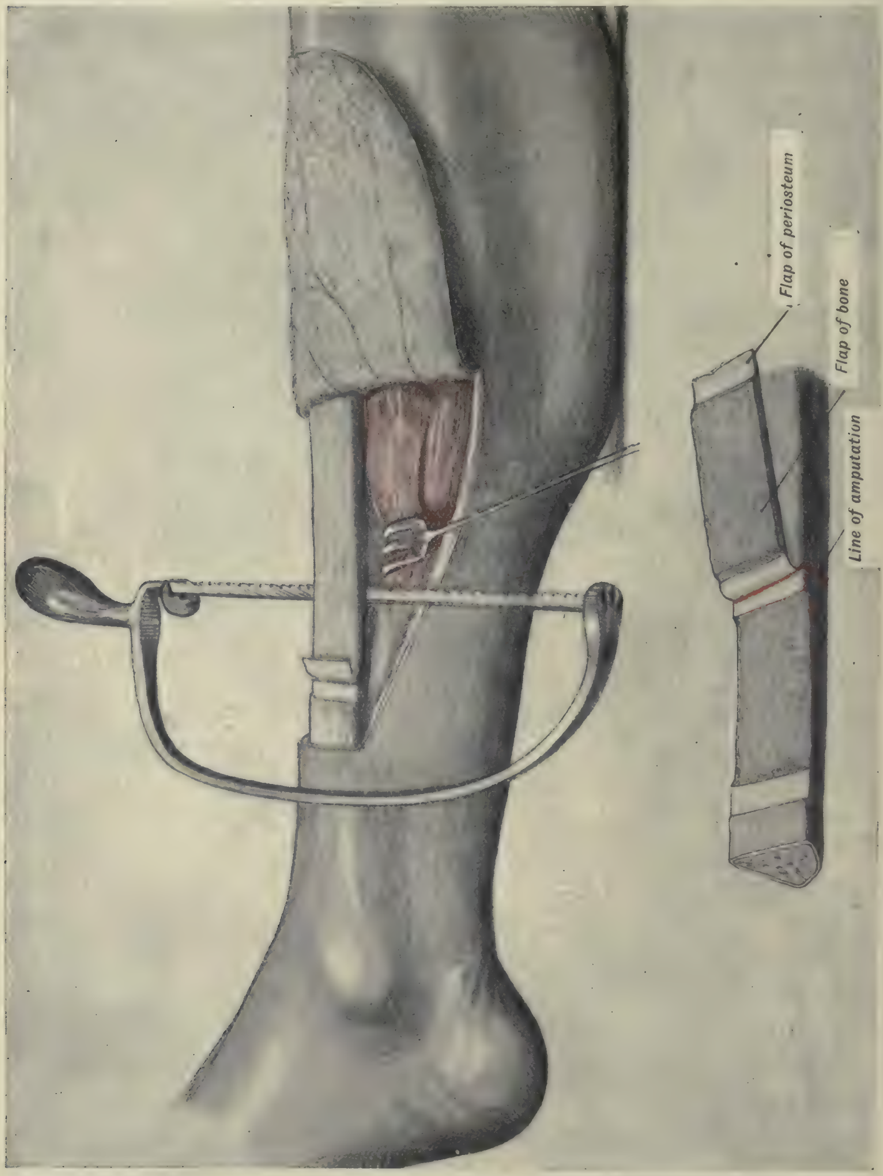

FIG. 109.—Bier's osteoplastic amputation of the leg. Stage I.: A flap of bone is sawn off with the fret saw; the inset represents the periosteal flap and the line of amputation.

There are other methods possible in addition to the chief ones we have described. The main differences are in the skin incisions, which may be made to suit every condition. Bruns begins by dividing skin and soft tissues, then with the help of two lateral incisions he separates all the soft tissues from the bones in the form of thick anterior and posterior flaps; these include the periosteum, which is stripped up for a distance of three finger-breadths. The bone is then divided as far up as possible. This stump is exceptionally well padded and really gives excellent results.

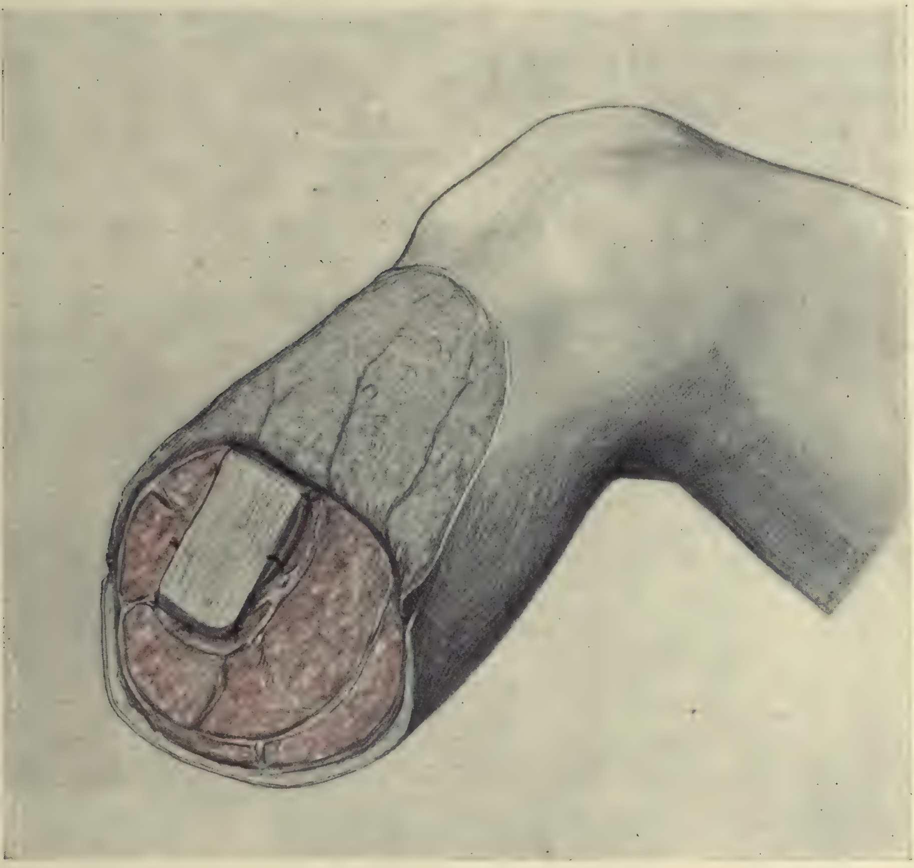

FIG. 110.—Bier's osteoplastic amputation of the leg. Stage II.: The sawn surfaces of tibia and fibula are covered in by the osteoplastic flap.

For amputation in the lower third of the leg Wilm's method of rounding off the sawn surface is simple and of real importance. He sutures the stump of the tendo Achillis firmly to the bone (a tendinoplastic method). Not only is the pad obtained by this method very durable, but the fixation of the tendo Achillis prevents any strong contraction of the muscles backward and guarantees what you are striving for, a mobile flap of skin opposite the scar.

8.' *Disarticulation at the Knee.*

If it is proposed to remove the leg at the knee, recall to mind the regional anatomy of the part and reconsider our description of excision of the knee (*v.* Fig. 64). A large flap is to be fashioned; the skin incision commences at the level of the joint fissure close behind the condyles and is carried round to the opposite side; it crosses the anterior border of the tibia about 3¼ in. (8 cm.) below the tibial tubercule. A posterior flap is made to correspond, but it is made much shorter. Raise the two flaps from the underlying tissues (*v.* Fig. 107*b*). As in the corresponding operation on the elbow joint we have to remember that the soft tissues of the flexor flap are elastic and unusually prone to retract; the beginner is always inclined to cut the flexor flap too short. Then flex the knee, cut across the ligamentum patella, enter the joint, divide the lateral and crucial ligaments and return the leg to the position of extension. Divide all the soft tissues at the back together with the vessels and nerves, using the typical amputation cut. The leg can now be removed. The popliteal vessels lie together on the cut surface and must be ligatured; the internal popliteal nerve is in close proximity to them, and the external popliteal lies to the outside; these nerves should be drawn down and divided at a higher level. (Cp. Fig. 15 for the topography of the popliteal space.) Cover the stump with the anterior flap of skin. It offers a splendid support, and it is all the easier to attach an artificial limb seeing that the patella is usually retained. If the latter be condemned, its excision presents no difficulties.

9. *Gritti's Amputation.*

Various amputations at the lower extremity of the femur have been brought forward as substitutes for disarticulation at the knee. Two methods (those of Gritti and Sabanejeff) conclude with an osteoplastic closure of the bone. They are both modifications of the Pirogoff procedure.

It is well to mention that Wilms after sawing through the lower end of the femur covers it with the quadriceps tendon; he frees it from the patella and sutures it to the periosteum on the posterior edge of the femur. The results are excellent; the method gives a good finish to the bone and ensures free mobility of the skin flap on the stump; it also prevents retraction of the extensor muscles.

Gritti's operation commences with the formation of an anterior flap of skin. Its base is at the level of the condyles, its apex somewhat below the tibial tubercule (*v.* Fig. 111). Raise the flap, flex the leg and penetrate the joint by dividing the ligamentum patellae and the lateral parts of the capsule. Now proceed at once to refresh the posterior surface of the patella. The best way of fixing it is to evert the flap and press it forward from the skin side with the four fingers of the left hand; grasp the ligamentum patellae with the thumb while the patella is being forced out of the wound. This enables one to remove the articular cartilage with a careful and even saw-cut. The next step is to saw the femur just above the condyles. Expose the anterior aspect of the bone, and then carry the knife backwards through the soft tissues at least a thumb's-breadth below the level of your intended saw-cut; bear in mind the strong contraction of the soft tissues at this point. Now saw the femur through. Stop all bleeding and treat the nerves as in disarticulation of the knee. Then turn back the anterior flap and stitch the stump of the ligamentum patellae to the periosteum at the back of the femur. The scar lies posteriorly. Figs. 111 and 112 are diagrams representing the course of the operation.

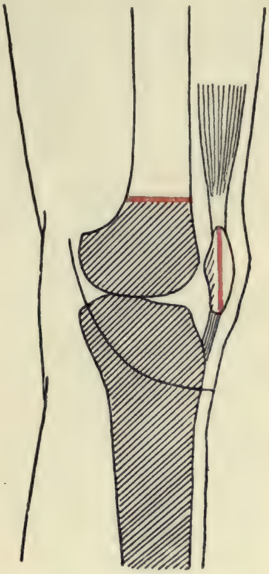
FIG. 111 —Diagram of Gritti's amputation.

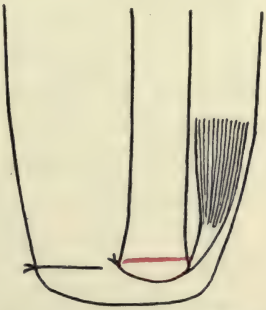
FIG. 112.—Diagram of Gritti's amputation.

10. *Sabanejeff's Amputation.*

This operation is only to be considered when the knee joint is intact and part of the head of the tibia is available. In the main it resembles Gritti's method. Figs. 113 and 114 illustrate the procedure. The skin incision is again placed anteriorly; but its base lies somewhat lower and its apex crosses the tibia three finger-breadths below the tibial tubercule. Before throwing up the flap saw off a large piece of the head of the tibia; it includes part of the articular surface of the joint as well as the tibial tubercule; its length should correspond roughly to the diameter of the femoral condyles. The further procedure is an exact replica of Gritti's method, except that the patella is left intact and the femur is sawn at the level of the condyles. Suture the flap and attend to the raw surface as in the previous operation. The tibial tubercule is accustomed to pressure and forms an excellent support. The method is represented diagrammatically in Figs. 113 and 114.

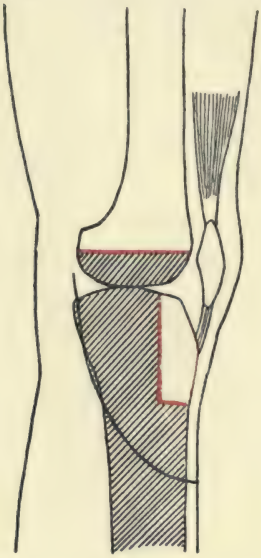

FIG. 113.—Diagram of Sabanejeff's amputation.

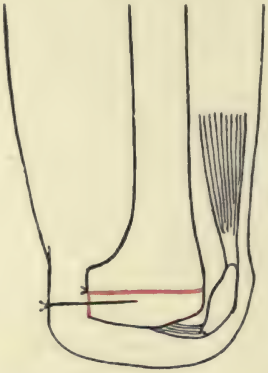

FIG. 114.—Diagram of Sabanejeff's amputation.

11. *Amputation of the Thigh.*

There are many ways of performing amputation of the thigh. The choice of method depends on (1) the level at which it is intended to amputate; (2) the degree of muscular development; and (3) whether we are working under aseptic conditions which enable us to carry out a primary formation of the stump.

Gritti's and Sabanejeff's are osteoplastic amputations through the lower end of the femur. Higher up the leg it is unusual to employ osteoplastic methods, the aim being to provide the stump with a thick pad of soft tissues. As the femoral stump has to bear the direct weight of the body it is undesirable to place the scar over the middle of the supporting surface. The double flap operation is therefore again to be regarded as the normal method (Fig. 115*a*). The anterior flap should be distinctly larger than the posterior; this of course makes the scar lie at the back, but in the after treatment it allows the ready escape of any secretions that may collect. We observe the general principles already described in the raising of the flaps. The leg is lifted at right angles to the body while they are being fashioned. We then return it to the horizontal, retract up the flaps firmly and with typical circular cuts make an even division of all the soft parts. According to the old rule the limb to be amputated should come away on the right side of the operator; for this reason he always places himself on the outer side of the right leg and on the inner side of the left one (which must therefore be abducted). The upper part of the thigh and the foot are now held firmly by the assistants and the bone is sawn across. Care must be taken to retract the soft parts firmly upwards, so that the bone is divided well up the leg; the best way is to use gauze compresses for pushing up the cut surfaces; the leg is to be raised during the sawing of the bone to let the muscles sink backwards with gravity. We usually round off the edges of the bony shaft with saw or bone forceps and scrape out the marrow with a spoon.

We can now attend to the large vessels and nerves seen in cross section: Fig. 116 gives a diagram of this. The quadriceps extensor lies anteriorly, the sartorius muscle lies internally. The main vessels are found at the posterior border of the latter, the artery lying in front and the vein behind: they are accompanied by the long saphenous nerve. The principal nerve is the great sciatic: it lies hidden in the group of the flexors, behind the biceps muscle. The muscles on the posterior side of the thigh are arranged in two groups, adductors and flexors (biceps, semimembranosus, semitendinosus, gracilis). Numerous arterioles, branches of the profunda femoris, lie in the different intermuscular septa and need to be secured in the living subject. (Cp. also Fig. 13 for the relations of the femoral artery).

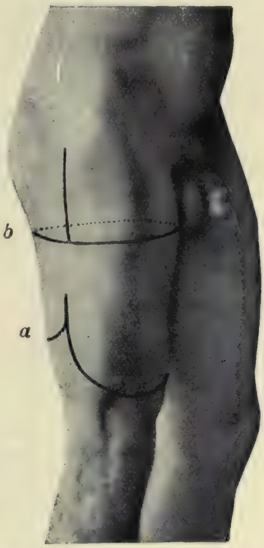

FIG. 115.—Incisions (a) for the amputation of the thigh by anterior and posterior flaps; (b) for disarticulation at the hip by the amputation-resection method.

Stop all hemorrhage, draw down the nerves, particularly the sciatic, and divide them high up. Then coapt the muscles over the end of the bone with stout catgut sutures, thus giving them a new point of insertion and preventing them retracting. Then lay the large anterior flap over the padded stump and suture it to the small posterior flap, edge to edge.

In very high amputations of the thigh the position of the scar is immaterial. For in these cases we do not subject the thigh to the direct weight of the body, but prefer to flex the stump and let the patient set his weight on the artificial limb: the latter is supported on the tuber ischii of the pelvis.

12. *Disarticulation at the Hip.*

This serious operation has been robbed of its chief danger; methods are now known by which we can render the part bloodless even in the highest disarticulations at the hip. Speed used to be the governing factor in the operation; and this led to the transfixion and flap transfixion methods.

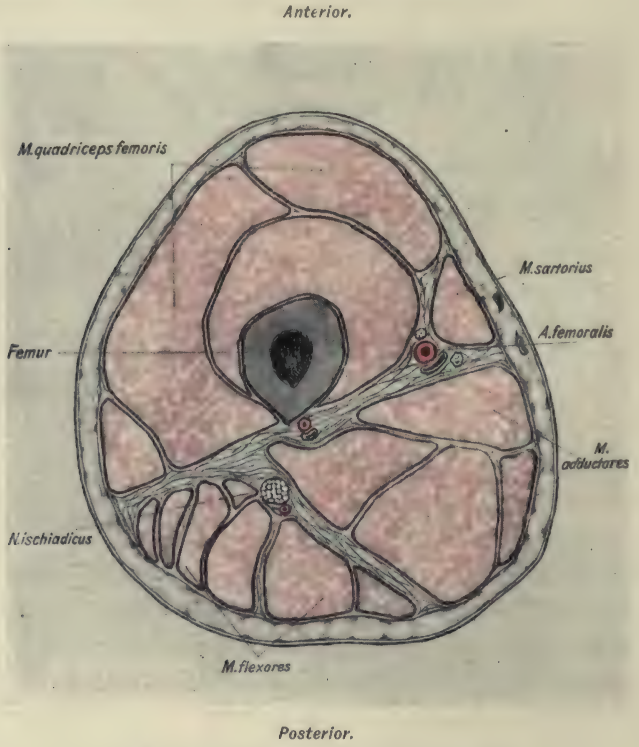

Fig. 116.—Cross section of the right thigh.

Just as in the shoulder joint, so also in the hip we employ the so-called amputation-resection method for choice (Fig. 115*b*). Render the part bloodless by applying an Esmarch spica round the top of the thigh and pelvis. Then rapidly do a high amputation, making a single skin incision and sawing the bone at the same level. Attend as usual to the vessels and nerves on the cut surface. Remove the Esmarch bandage. Then run a linear incision to meet the circular one, as shown in Fig. 115*b*; commence it above the trochanter major and divide all the soft parts right down to the femur. This linear cut corresponds to v. Langenbeck's incision for resection of the hip.

An assistant now retracts the soft parts along the linear incision. The operator grasps the bony stump with lion forceps and rotating it alternately in and out he frees it all round from its muscular attachments as far up as the femoral neck. He opens and divides the articular capsule. He incises the cotyloid ligament, displaces the head, cuts or tears away the ligamentum teres from the socket and completes the separation. The procedure reminds one of the excision previously described. On closing the large wound we get a muscular stump, traversed by a cross and a lateral linear suture. The above method is the only one to be employed when the soft parts in the immediate vicinity of the wound are sufficiently healthy to be retained. But when they have to be condemned right up to the pelvis, the so-called extirpation method should be employed. It used to be the rule to begin by attacking the femoral artery and vein or even to go higher still and perform a typical exposure and ligature of the external iliac artery and vein. Momburg's modern bloodless method is an excellent one. Under certain precautions a bandage is fastened round the loin, and the aorta compressed during the time of operation. Whether preliminary devascularisation is done or not, however, we recommend the operator to employ an anterior flap incision (*v.* Fig. 117), to separate the flap up to Poupart's ligament and divide the soft parts on the front of the thigh layer by layer and then open the hip joint from the front. Disarticulation is easy and is done in the usual way. In shaping the posterior flap divide the soft parts from within outwards, the extent of disease determining whether the posterior flap should be larger or smaller than the anterior one; if the disease has reached a high level divide the tissues close to the pelvis. Attend to the vessels and nerves. The entire limb and the soft parts on the outside of the leg having been removed it will be found easy to cover the one half of the pelvis with the anterior and posterior flaps.

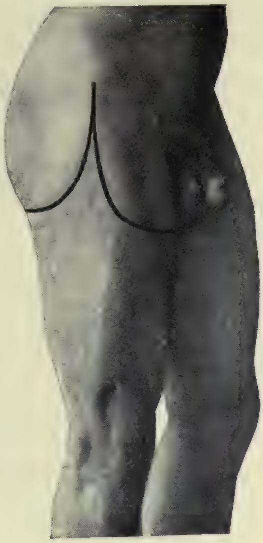

FIG. 117.—Anterior and posterior flap incisions in high disarticulation of the hip.

SECTION IV

VARIOUS OPERATIONS ON THE EXTREMITIES

1. *Tenotomy.*

TENOTOMY or tendon division can be done either by the open or the subcutaneous methods. We begin with subcutaneous tenotomy. Small knives, called tenotomes, are used for this purpose (cp. Figs. 118–120). The aim of the operation is to divide the extended tendon through as small a skin incision as possible. It is most frequently performed on the tendo Achillis, where it may be practised on the subject. The operator grasps the dorsum of the foot with the left hand, dorsiflexes the foot strongly and puts the tendo Achillis well upon the stretch. He holds the pointed tenotome in the right hand and makes a stab wound from one side or the other a thumb's-breadth above the insertion of the tendo Achillis. The guarded tenotome is then introduced through the small opening in the skin and applied to the anterior surface of the tendon; the site of the puncture is illustrated in Fig. 121*a*. The rigid tendon is divided with light sawing movements in an antero-posterior direction, the thumb being placed at the same time on the tendo Achillis to catch the knife as soon as it severs the tendon completely (cp. Fig. 122); a sharp jerk indicates the moment at which this occurs. The small skin wound should not be enlarged at all. We learnt from the ligation of the vessels that the posterior tibial artery

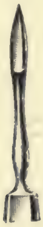

FIG. 118.—Sharp-pointed tenotome.

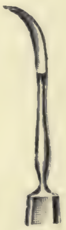

FIG. 119.—Sharp-pointed tenotome.

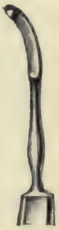

FIG. 120.—Blunt-pointed tenotome.

runs down between the tendo Achillis and the internal malleolus and is accompanied by the posterior tibial nerve. These two structures can be easily avoided by adhering closely to the tendon.

The open method is advisable where tenotomy is to be performed in the immediate neighbourhood of vital arteries, veins or nerves; instance the tenotomy of the sterno-mastoid in cases of wry neck, where the subcutaneous method has been given up on account of the proximity of the external jugular vein. A small transverse incision is made close above the origin of the sterno-mastoid muscle: the tendon of the muscle is exposed, and the bundles of tendinous fibres taken up gradually on an aneurism needle till the whole of the tendon has been divided.

2. *Tendon Suture and Tenoplasty.*

It is easy to suture a transversely divided tendon. If the cut surfaces are smooth and the wound a clean one we can proceed at once to stitch the tendon; lacerated or shredded ends cannot be sutured till the cut surfaces have been refreshed and rendered smooth. In cases where the ends of the tendons have retracted up from the edges of the wound, we are sometimes obliged to make additional linear cuts through skin or tendon sheaths in order to find the ends: any fresh slipping back is prevented by the introduction of a stay suture. The best way to practise tendon suture in the dead subject is to make a deep wound across the flexor aspect of the wrist joint and proceed to repair the damage inflicted. If the tendons divided are thick ones they are to be accurately coapted and fixed in the simplest way, by using two adjacent sutures (Fig. 123) or inserting them at right angles to each other (Fig. 124). More elaborate methods are superfluous. In the case of thin flat tendons with a small cut surface, they are laid side to side as shown in Fig. 125. In tendon stitching it is best to employ medium silk and small round needles; these leave only small holes behind.

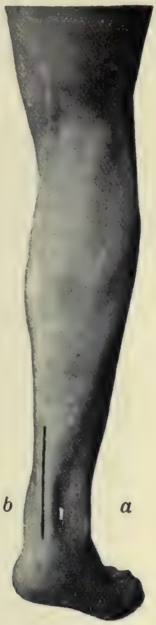

FIG. 121.—Incisions in operating on the tendo Achillis: (*a*) for subcutaneous tenotomy; (*b*) for plastic elongation.

Instead of simple tenotomy the surgeon may attempt a plastic elongation of shortened tendons, in order to establish tissue continuity. Expose the tendon and make a Z-shaped cut through the tendon (Bayer's tenotomy) (cp. Fig. 126). On drawing the two halves apart the ends of the split tendon can be coapted with a single suture (Fig. 127). The method is frequently practised. In the dead subject it can be performed on the tendo Achillis by means of a linear skin incision as shown in Fig. 121*b*. This method of tendon lengthening can also be carried out subcutaneously. Cut the tendon half through from the one side close above the calcaneal insertion, and notch it from the other side some two to three finger-breadths above this; it is then possible to lengthen the tendon by strong dorsiflexion of the foot from the position of Fig. 126 to that of Fig. 127.

If the tendon has been already divided plastic elongation is more difficult. Direct suture may be impossible on account of loss of tissue or strong contracture. In this case one must cut a plastic flap, as shown in Fig. 128, from one or both ends of the tendon, and re-establish continuity by folding down the flap and suturing it in place (Fig. 129). One can successfully repair a defect in a tendon by bridging it across with stout silk sutures and entwining them together. These sutures are not absorbed: they act as foreign bodies round which the tissues heal; they form the centre of a strong strand of connective tissue and this functionates as a tendon.

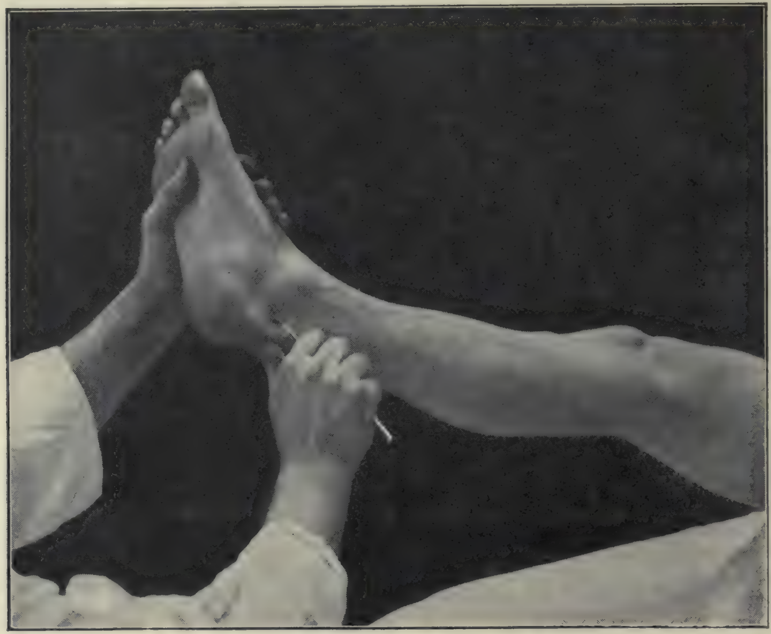

FIG. 122.—Subcutaneous tenotomy of the tendo Achillis.

Tendon transplantation (Nicoladoni) is the last of the tendon operations we shall refer to. It is used in cases of paralysis. It consists in utilizing the strength of a sound muscle by carrying it across to the paralyzed muscle and stitching the two tendons together. On dividing the two tendons we are able to connect the central end of a sound though unimportant muscle with the peripheral tendon of a more important and paralyzed one. This is

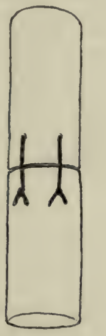

FIG. 123.—Tendon suture with two adjacent stitches.

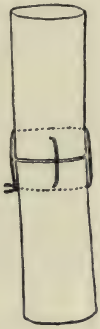

FIG. 124.—Tendon suture with two crossing stitches.

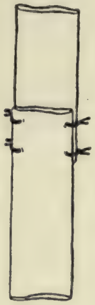

FIG. 125.—Suture of a flat tendon.

a great advantage. It is usual to retain the active muscle in its entirety, but to divide the tendon of the paralyzed one and apply its distal end to the side of the active tendon. The tendons can be entwined as shown in

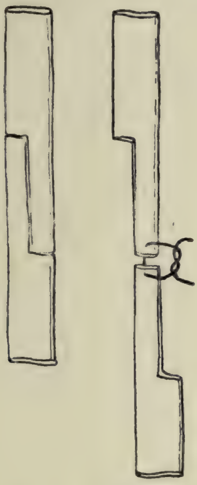

FIG. 126. FIG. 127.
Plastic elongation of a tendon.

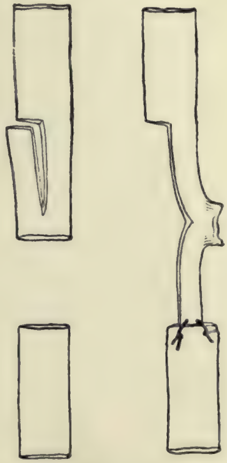

FIG. 128. FIG. 129.
Plastic elongation and suture of a divided tendon.

Fig. 130. The active muscle now supplies two tendons. The active muscle is now divided and its central active end stitched to the tendon of the paralyzed muscle ; finally, we take the peripheral end of the active muscle and stitch it to an active neighbouring muscle. This can be practised on

the tibialis anticus, for example, assuming that it is the one paralyzed. Expose the tendon above the annular ligament and unite it to the central end of the divided extensor longus hallucis. In order to preserve the function of the extensor hallucis we stitch its peripheral end to the extensor longus digiturum (assuming the latter to be sound). The position and line of pull of the functionating muscle may be far removed from that of the weak one ; it is then often necessary to split up the former into more or less equal halves, running the cut right into the muscle belly before the correct action is attained. An idea of this method can be got from practice on the subject. Suppose, for example, the peronei muscles are paralyzed and that we have to connect the peronei tendons with the split tendon Achillis. It falls to be noticed that pretty large skin incisions are demanded for good tendinoplastic work ; the affected tendons are then thoroughly exposed in their long axes. It is always well to coapt the tendons with the foot in a position of tension.

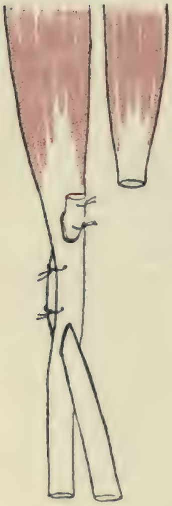

FIG. 130.—Tendinoplasty : the tendon of the paralyzed muscle has been sutured into the tendon of the functional muscle.

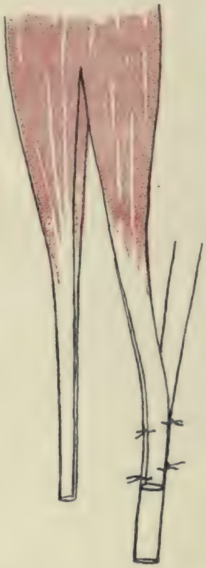

FIG. 131. — Tendinoplasty : a functionating muscle has been split and one half of the tendon stitched to the paralyzed tendon.

Another method is the periosteal transplantation of tendon (after Lange). It aims at the fixation of an active muscle to a new point of insertion ; the muscle is divided at its peripheral insertion or in its continuity and is fastened by periosteal suture. The paralyzed muscle is left intact.

3. *Operations on the Chief Nerve Stems.*

Operative interference is often required in cases of the large nerve stems, but it is only in a few instances that the operation can be practised on the dead subject. Let us begin by referring to nerve suture. Before suturing a divided nerve we have usually to refresh the cut surfaces and make them even : in old-standing nerve lesions the ends of the nerve are found embedded in scar tissue and the club-shaped ends have to be carefully excised. The nerves are next put on the stretch, the ends approximated, the cut surfaces coapted and then fixed in place with a couple of reliable sutures, passed through the middle of the nerve (just like tendon stitches, Figs. 123 and 124). Formerly, surgeons made a point of confining themselves to the so-called perineurotic suture, *i.e.* to stitch up only the connective tissue sheath in suturing cut surfaces. The least stretching spoils the operation ; one must therefore stitch the substance of the nerve itself. It is also advisable to supplement this primary suture with a few perineurotic stitches, because coaptation is then more exact. The technique of this operation is best practised by exposing the median nerve at the wrist (*v.* Fig. 133).

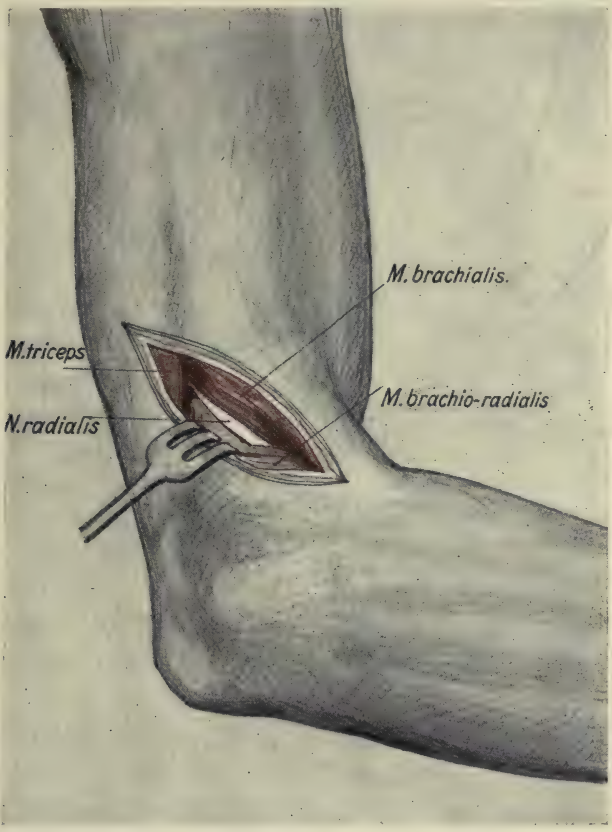

FIG. 132.—Exposure of the musculo-spiral nerve at the outside of the upper arm.

Neuralgias of nerve trunks can be treated effectually by the operation of nerve stretching. This is performed chiefly in the case of the sciatic nerve ; the requisite technique is described in the chapter dealing therewith.

Division of nerves is the usual treatment for the most severe types of neuralgia; this is done under definite precautions and only in certain nerve trunks. A still more effective way is to extirpate the nerve, or draw it out (Thiersch's method): compare the chapter on neuralgia of the trigeminal (Part V., A 4 and B 1). Radical measures of this kind are not performed unless to relieve neuralgias or cramp movements in amputation stumps. In these cases the loss of motor function that ensues can be disregarded.

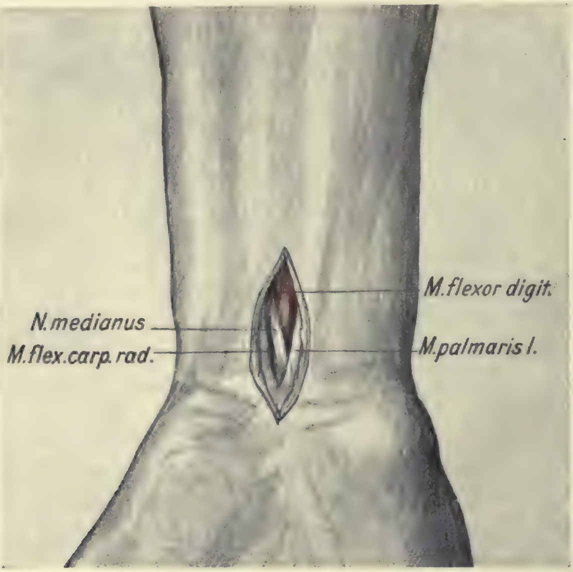

FIG. 133.—Exposure of the median nerve at the wrist.

In the dead subject the main thing is to expose those peripheral nerves that are of importance in the practice of surgery.

(*a*) *Musculo-spiral nerve* (*N. radialis*).

The musculo-spiral has been already encountered in the axilla (Fig. 24). Issuing from the posterior cord of the brachial plexus, it runs backwards in the axilla, courses round the humerus in spiral fashion and proceeds on in the external bicipital furrow to reach the flexure of the elbow. After giving off various muscular branches it leaves the elbow and divides into its two terminals: (1) the radial nerve (which accompanies the radial artery), and (2) the posterior interosseous nerve (which runs downwards and backwards through the supinator brevis to supply the extensor muscles at the back of the forearm, cp. Fig. 89). As it winds round the humerus it lies in contact with it and it is therefore often implicated in disease or in fractures of the bone (compare its position in the cross section of the arm, Fig. 91). It is specially important that we should be able to expose it on the outside of the arm above the elbow joint. We will therefore practise the typical operation at this point.

Flex the arm at the elbow. Palpate the biceps muscle and the bicipital tendon as it descends to the radial tuberosity. Palpate also the supinator longus. Incise in the furrow between these two muscles: the cut should be a spiral one and should extend upwards, as shown in Fig. 132. The triceps is seen in the upper angle of the wound and is retracted outwards. Two muscles are now seen in the depth of the wound, their fibres more or less parallel to the line of the skin incision; these are the supinator longus and the brachialis anticus. The line of separation between them is marked by a septum, but this may be difficult to find. Separate the two muscles in this line with blunt retractors and the nerve comes into view; it lies near the bone at this point (cp. Fig. 132).

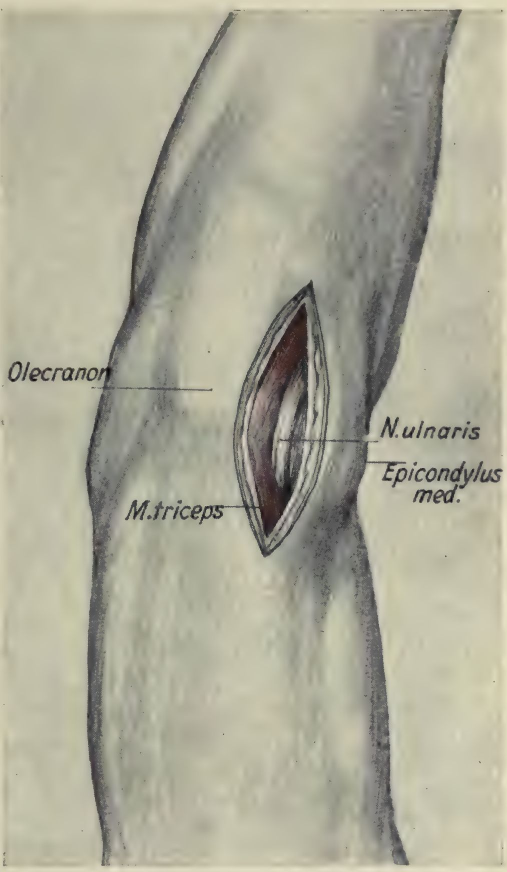

Fig. 134.—Exposure of the ulnar nerve at the elbow.

(*b*) *Median nerve.*

We saw how the median nerve accompanies the brachial artery and only leaves it at the flexure of the elbow. The same rule applies for exposing it in the upper arm as in the case of the artery (compare Figs. 24 and 26, and the cross section of the upper arm, Fig. 91). In the forearm it lies between the superficial and deep flexors (*v.* cross section of the forearm, Fig. 89), and in the tendinous portion of the arm close to the wrist it lies immediately under the deep fascia. We expose it here in the dead subject, as this is the most important place in surgical practice. Make a 1¼-in. to 1½-in. incision (3 to 4 cm.) exactly in the middle of the flexor aspect, incising as far as the anterior annular ligament. The nerve is a stout one, and on division of the fascia it is found lying between the tendon of the flexor carpi radialis and the thin tendon of the palmaris longus (*v.* Fig. 133).

(*c*) *Ulnar nerve.*

The ulnar nerve is exposed by the same incision as is used for the artery. Its relations to the blood-vessels are seen in Fig. 24 and the cross section in Fig. 91. It lies on the triceps and runs downwards and backwards ; it crosses the elbow-joint close to the tendon of the triceps, lying in the ulnar groove. Here it lies on the extensor side of the arm, between the olecranon and the internal epicondyle. It is placed just under the skin and can be palpated as it lies on the bone. We met it during the excision of the elbow (*v.* Figs. 56 and 57). A $1\frac{1}{4}$-in. incision (3 cm.) through skin and aponeurosis is sufficient to expose it (*v.* Fig. 134).

As the diagram in Fig. 26 illustrates, the ulnar nerve meets the ulnar artery in the forearm about the junction of its upper and middle thirds and accompanies it downwards. See also the cross section of the forearm (Fig. 89).

(*d*) *Great sciatic nerve* (*N. ischiadicus*).

The sciatic nerve is the largest nerve trunk in the body, being almost as thick as the little finger. It arises from the sacral plexus by the fusion of independent nerves ; it escapes from the great sciatic foramen usually in the form of a single trunk ; it then escapes from under the pyriformis muscle and runs vertically downwards at the back of the thigh, lying concealed among the flexors. It is sought at the gluteal fold, where it rests on the adductors and is covered by the biceps muscle.

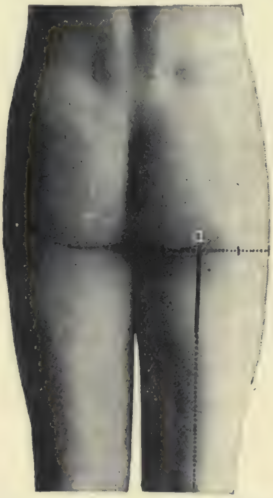

FIG. 135.—Incision for the sciatic nerve.

The subject lies prone. The operator palpates the tuber ischii and the tip of the great trochanter of the femur, and draws a line between them (*v.* Fig. 135). Trisect this line, and from the point *a* draw a line straight downwards towards the middle of the popliteal space : this corresponds to the course of the great sciatic nerve. Make the skin incision in this line, commencing it a little above the gluteal fold and carrying it downwards through the thick skin and fat till the oblique inferior border of the gluteus maximus is seen. Continue the division of the deep fascia downwards till you reach the longitudinal muscles of the thigh. The outer border of the biceps is now seen, its fibres slanting down and outwards from the tuber ischii. Retract the edge of the muscle inwards, and expose the great sciatic nerve beneath it : it lies embedded in loose connective tissue, and it is easy to raise and hook it up from the underlying adductors (*v.* Fig. 136). This operation is usually undertaken with a view to stretching the nerve in cases of neuralgia (sciatica). The stretching is effected by hooking up the nerve with the bent forefinger and tugging it upwards and downwards till the whole leg is lifted off the operating table by the nerve. To understand the position of the sciatic nerve compare also the cross section of the thigh (Fig. 116).

(*e*) *Posterior tibial nerve* (*N. tibialis*).

The sciatic divides into posterior tibial and external popliteal nerves above the level of the knee joint. The former takes a straight course downward into the popliteal space. It is shown in Fig. 15, and has been already seen in the exposure of the popliteal artery. It accompanies the posterior artery right down, as is evident from Fig. 19. No special directions are needed for exposing it.

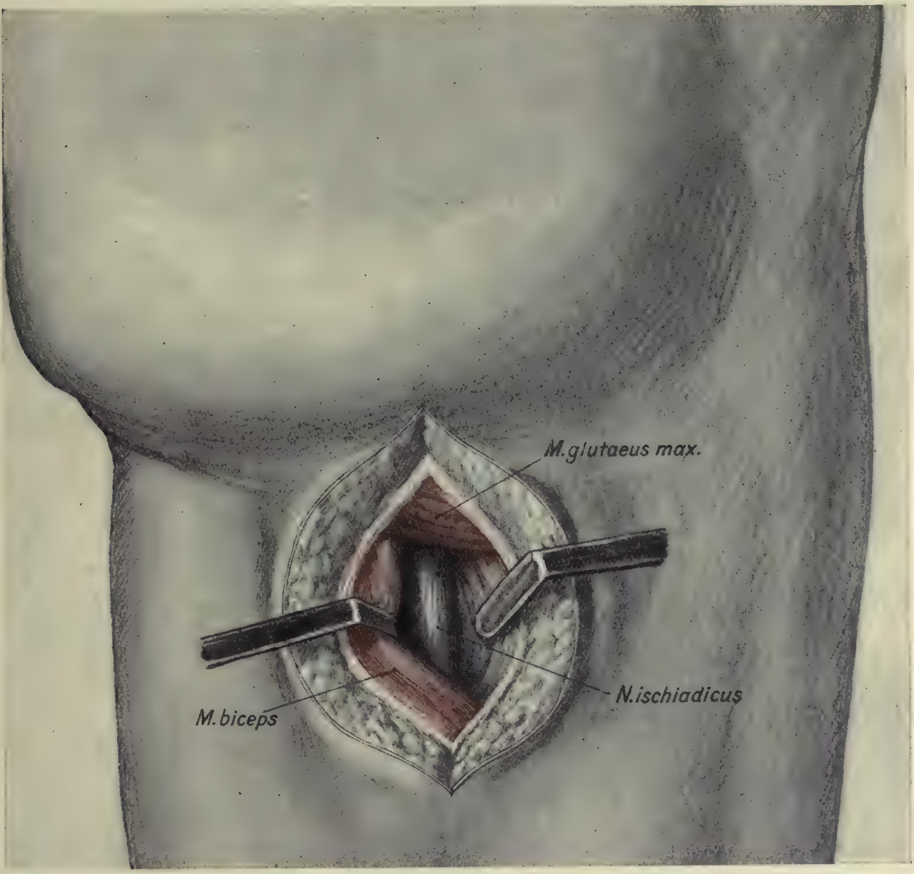

FIG. 136.—Exposure of the sciatic nerve.

(*f*) *External popliteal nerve* (*N. peroneus*).

The other division of the sciatic nerve is of far greater surgical importance. It divides a little below the middle of the thigh, slants downwards and outwards along the inner border of the biceps muscle, and can be exposed by an oblique incision in the popliteal space. It passes thence to behind the head of the fibula, sweeps round the fibular neck and eventually accompanies the anterior tibial artery. We see it associated with this artery in Fig. 17. It is usually exposed at the point where it crosses the head of the fibula. The skin incision is somewhat oblique. Starting opposite and behind the top of the fibular head it takes a spiral course round the fibular neck Divide the tendinous fibres that spread out from the insertion of the peroneus longus and the nerve will be found between the two parts of that muscle, lying close to the bone (*v.* Fig. 137).

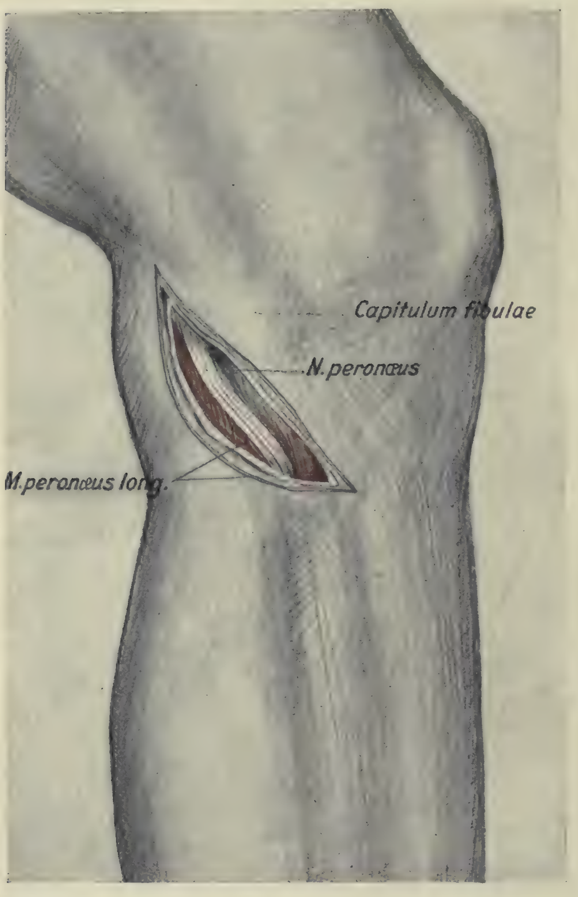

FIG. 137.—Exposure of the external tibial nerve at the head of the fibula.

4. *Vessel Anastomosis.*

Ligation of arteries is practised in the first part of the book. If the vessels exposed to injury be large ones we are no longer restricted to a simple ligation of the vessel above and below, done in order to stop the blood from circulating: we have learned to practise conservative surgery even in the case of the blood-vessels. It behoves us to consider lateral ligation in this connection. By this is meant the catching up of an aperture in the side of a vessel with special forceps (Figs. 75 and 76), and the encircling and closure of the projecting cone with a reliable lateral suture (*v.* Fig. 138). We can only expect the method to be successful when the hole is small. Speaking generally, the method is applicable only to veins. It has been replaced almost entirely by the method of lateral suture, as shown in Fig. 139, which is particularly suited for longitudinal cuts. Rapid healing should occur in the blood-vessels, provided the intima has not been injured and thrombi have not formed ; but a necessary condition of this is to appose intima to intima by folding the edges of the wound outwards : (the opposite holds good in the intestine where the edges are invaginated).

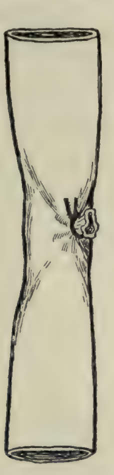

FIG. 138.—Lateral ligation of a blood-vessel.

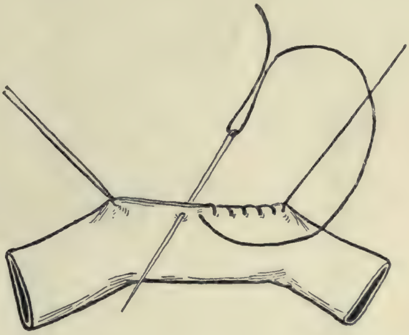

FIG. 139.—Lateral suture of a blood-vessel.

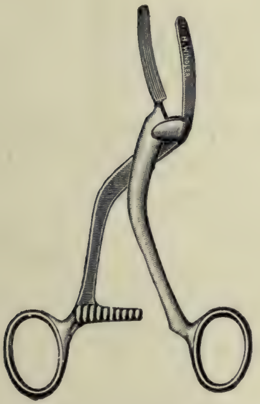

FIG. 140.—Vessel clamp (Höpfner's).

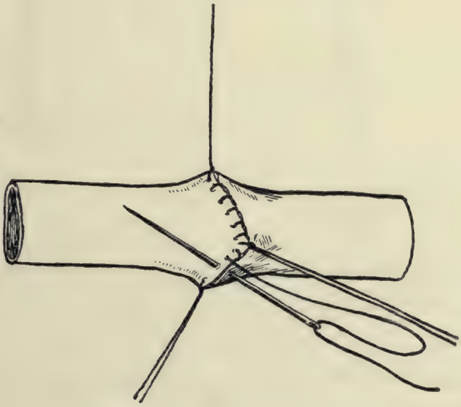

FIG. 141.—Circular arterioraphy.

The suture itself is done with an extremely fine needle and the very finest silk. The line of suture is now put on the stretch by a couple of stay threads, and the operation completed by the introduction of a fine silk suture ; this should be close and continuous and should press intima against intima. The vessel is to be temporarily occluded during the operation by applying a pair of delicate rubber-guarded clamps above and below (cp.

Fig. 140); Höpfner's clamps are the best. One of the triumphs of modern surgery is the circular vessel stitch introduced by Carrel; it has supplanted the older methods. After temporary occlusion of the blood-vessel, the circular lumen is divided up into an equilateral triangle by the insertion of three sutures and the three sides are then stitched on the same principle as in lateral suture, *i.e.* by a continuous stitch of fine silk. The more the tissue is preserved, the less the likelihood of subsequent contraction. If the puncture wound go on bleeding after the stitching of the vessel is finished apply a moist compress for five minutes; the threads are then so swollen that bleeding is prevented. It is of the utmost importance to see that no tags of the adventitia are allowed to enter the line of the suture or the lumen of the vessel; the outer coat is therefore drawn well back or removed for some distance from the edge of the wound. The only other important method is that of Payr, who employs a ring of magnesium over which he ligatures the vessel; the cut ends of the vessel are fixed to this in such a way that the ring comes to lie extra-vascular, and the intima is kept intact in its entire continuity. Any after-bleeding is thus prevented.

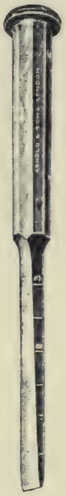

Fig. 142.—Macewen's osteotome.

Fig. 143.—Wooden mallet.

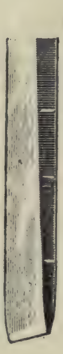

Fig. 144.—Fig. 142 enlarged.

It is best to practise the surgery of the blood-vessels on the large femoral trunks. They can be exposed for quite a distance.

5. *Osteotomy.*

By osteotomy is meant the division of a bone in its continuity. It is carried out in order to strengthen long bones that have become bent either from changes in the bones or from fixation of the joints. The most frequent site for osteotomy is at the knee, to relieve genu valgum. The experience of many surgeons has led us to formulate the rule that the extra-articular method is to be followed in all osteotomies.

First, as regards the general technique, osteotomies are divisible into open and subcutaneous. By the "open" method is meant the chiselling and exposure of the bone under the guidance of the eye; it is done as follows: Make a linear incision, avoiding undue injury to the soft parts. Penetrate through the periosteum and reach the bone. Force up the periosteum a little way on each side, and retract it with blunt hooks or a pair of broad elevators. The operator now strikes through the bone with a broad straight osteotome in any direction he likes. He employs the instruments shown in Figs. 142 and 143. For linear osteotomies it is well to use an instrument after the pattern of Macewen's osteotome (Fig. 142); the shape of this instrument is shown in section in Fig. 144, and it enables us to chisel directly in the line of its axis.[1] We are not anxious to chisel the whole circumference of the bone: we prefer to leave a thin bridge standing, which is either broken through after all the instruments have been removed, or merely bent. The fragments remain to a certain extent in contact: this prevents any great displacement and allows of the immediate impaction of the fragments. A simple transverse or oblique division of the bone (linear osteotomy, as it is called) is not sufficient in cases of considerable curvature; a wedge of bone has then to be chiselled out with its base at the convexity of the bend. For this purpose we can employ either the Macewen osteotome or the chisel whose shape and section are shown in Figs. 145 and 146. The remaining bridge of bone is bent or fractured as above. Wire sutures are only required in exceptional cases. The edges of

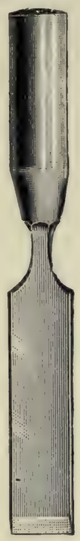

FIG. 145.—Joiner's chisel.

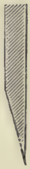

FIG. 146.—Cross section of joiner's chisel (bevelled on one side).

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[1] The osteotome is a more conservative instrument than the chisel: it acts in the cancellous tissue like a wedge and does not splinter the bone.—TR.

the periosteum are drawn together with a few sutures and the soft tissues and skin coapted.

Subcutaneous osteotomy should always be carried out with the Macewen osteotome (Fig. 142); the skin incision is very small, and the bone never comes into view at all. The limb rests as in open osteotomy upon a sandbag; this acts as an unyielding support during the chiselling and is the best way of guarding the tissues from injury. Choose a spot for the incision where you know there are no important vessels and nerves, and make a stab wound down to the bone; this short linear incision can be enlarged at will. Keep the blade of the knife in contact with the bone; the knife can then be used as a guide and a straight osteotome of medium size introduced along it down to the bone. The knife is not to be withdrawn till the osteotome is found resting on the bone. Grasp the osteotome firmly and rotate it some 90° till it rests in contact with the bone at right angles to the shaft. Grasp the osteotome with the fist and lean the wrist on the leg: this prevents the instrument from gliding in too deep, for the fist is stopped by abutting against the musculature. Then chisel the bone with sharp strokes of the mallet, the idea being to chisel through first the anterior and then the posterior circumferences of the shaft; the osteotome can be extracted by gripping the fingers tightly round it. It is then easy to break the rest of the bone. Avoid chiselling into the marrow. The wound is small and usually requires only a single deep stitch.

To carry out an osteotomy correctly it would be necessary to have a dead subject with bent limbs; but the essential steps can be performed even on a normal subject. As examples of subcutaneous linear osteotomy we shall describe subtrochanteric division of the femur (for malposition in ankylosis of the hip), and the supracondylar osteotomy of the femur after Macewen (for genu valgum).

For subtrochanteric osteotomy place the subject on the sound side and palpate the tip of the great trochanter. Take a point three finger-breadths below this in the adult and make the usual stab wound through skin, fascia lata and muscles down to the bone. Complete the division of the bone in the way we described above: the line is shown diagrammatically in Fig. 147*a*.

In Macewen's supracondyloid osteotomy the chiselling is done from the inner side of the leg. Place the subject on the dorsum, rotate the leg as far out as it will go, flex the knee and place a small sandbag beneath it. Palpate the upper border of the internal condyle of the femur and feel for the tendon of the adductor magnus muscle, which is inserted at the adductor tubercule. The bone should be divided immediately above the condyles (*v.* Fig. 147*b*).[1] Make the usual stab wound at this level and a finger's-breadth in front of the adductor tendon; the articular capsule and the extensor muscles lie in front of the tendon, and the great vessels lie behind it in the popliteal space. Carry out a subcutaneous linear osteotomy at this point according to the rules given above, seize the limb above and below and bend or break the remaining bridge of bone in an inward direction. Avoid over-stretching and injuring the external popliteal nerve. The bridge of bone having been bent over we proceed to correct the position of the limb; we aim at an impaction of the bony fragments.

Open osteotomy for the removal of a wedge of bone is mainly employed for rachitic curvatures. It is best practised on the tibia. Fig. 147*c* shows the way in which the bone is to be chiselled a little below the upper epiphysis. A linear incision is the rule, as this conserves the soft tissues.

6. *Necrotomy* (*Sequestrotomy*).

A frequent operation is to chisel into and remove the bone marrow in osteomyelitis or in excavating of central abscesses in the bone. The six long bones are the ones chiefly affected. Generally speaking linear incisions are the rule; it is thus possible to preserve not only the muscles and tendons but also the large vessels and nerves. Run the cut through the periosteum on to the bone, strip up the periosteum on each side with the elevator and open the marrow cavity in the region chiefly affected by chiselling away the anterior wall of the bone; use a gouge with a wooden grip (so-called joiner's gouge, Fig. 148) and a heavy mallet. Separate the soft parts with sharp retractors. The diseased marrow is scraped out with sharp spoons.

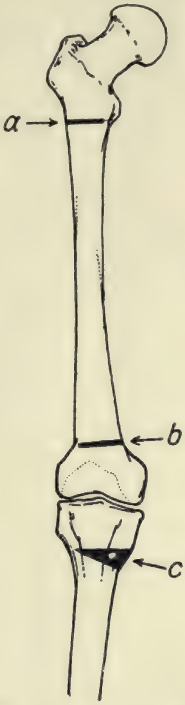

FIG. 147.—(*a*) Subtrochanteric osteotomy of the femur; (*b*) supracondyloid osteotomy of the femur; (*c*) wedge-shaped osteotomy of the tibia.

It is easy to practise this operation on the dead subject, even though there is no disease present. One can become acquainted at the same time with the proper treatment of the wound. Experience teaches that it is difficult for large cavities in the bone to cicatrise, especially if they run to any great depth, as is usually the case in the sequestrum cavities often present in the tibia. The surgeon is accordingly anxious to convert the groove in the bone into a trough, so he planes off the edges to enable the adjacent soft parts to be approximated and folded in; the chiselling is done with large gouges. Although this reduces the strength of bone materially it greatly improves the final result, provided one avoids fracturing the bone in the process. The upper and lower ends of the tibia are the parts that are most difficult to cover with skin. There is here often a sinus of suppuration extending to the epiphyseal line; it is impossible to remove the bony walls of the sinus, for we dare not on any account penetrate the neighbouring joint. To meet the difficulty Neuber has planned a Y-shaped incision as represented in Fig. 149. He completes the operation on the marrow cavity and then turns down the tongue-shaped flap of soft tissue into the deep groove, nailing it down in that position with a small steel pin. The part most reluctant to heal thus gains a fresh blood supply from the front. This method should be practised on the subject.

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[1] The division is made a finger's-breadth above the adductor tubercule, which lies on the epiphyseal line. The epiphysis must not be injured.—TR.

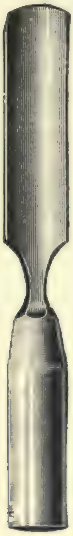

FIG. 148.—Gouge.

Let us now state the rules that are of special importance in the exposure of the six long bones. We start with the tibia as it is the most important. Unless another method is prescribed by special circumstances, a linear incision should be made upon the anterior and inner surface of the tibia; the bone lies under the skin in its whole length, and even the most reckless operator should escape doing injury (cp. the cross section, Fig 108).

The fibula should be exposed from the outer side. It is covered with muscles except at its upper and lower ends, and these muscles are to be divided in a longitudinal direction in the line of pre-existing septa. Remember that the external popliteal nerve bears a close relation to the head of the fibula. It must be exposed (Fig. 137) before any chiselling can be undertaken in this region. To preserve the nerve further down the leg and its branch, the fibularis communicans, one should attack the bone in its upper half by entering behind the peronei muscles, and in its lower half by penetrating between the peronei and the tendons of the extensors. The lower third of the bone lies immediately under the skin.

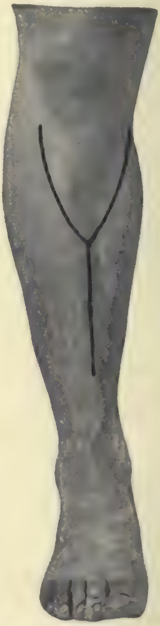

FIG. 149.—Neuber's Y-shaped incision for necrotomy in the vicinity of the epiphysis.

Chiselling of the femur is done from the outside in the whole length of bone. On this side there are no vessels or nerves to be damaged, though after the fascia lata is divided we are usually obliged to incise through a thick layer of muscle. Our aim is to penetrate behind the vastus externus, the biceps muscle being retracted backwards. During the operation the subject lies on the side.

In the upper extremity necrotomy is easiest in the case of the ulna. It is comparable with the operation on the tibia, since the bone lies under the skin in its whole extent from olecranon to styloid process. The only thing to guard against is a reckless division of the dorsal branch of the ulnar nerve; this branch passes from the flexor to the extensor aspect just above the wrist and crosses obliquely over the ulna.

A conservative exposure of the radius is more difficult, seeing that the whole of the shaft is covered with muscles. On pronation and supination of the forearm the radial head can be felt rotating just distal to the external condyle of the humerus; there is no danger in making a linear incision and entering at this point. The radius is easily exposed at its lower end near the styloid process by a linear incision, followed by retraction of the tendons. In the middle third one has to preserve the numerous branches of the musculo-spiral nerve; this divides just below the elbow joint into its terminal branches, being overlapped at this point by the supinator longus muscle: the superficial branch (radial nerve) is sensory, the deep branch (posterior interosseous) is motor and supplies numerous twigs to the extensor muscles of the forearm. To preserve them it is best to place the incision for the middle third of the bone between the extensor carpi radialis brevior and the extensor communis digitorum.

Lastly, exposure and necrotomy of the humerus is a very important operation. In this case it is the musculo-spiral nerve that has to be avoided. The latter takes a spiral course, and is to be sought in its typical position (*v.* Fig. 123), in every extensive exposure of the humerus and displaced with a blunt retractor. We then proceed inwards at the external bicipital groove and expose the bone between the biceps and brachialis anticus muscles.

7. *Suture of Bone.*

The periosteum should be preserved in every operation where we are aiming at the reunion and healing of bone. This rule has special force in the suture of bone. The periosteum should never be stripped up in the temporary division of a bone, *e.g.* the lower jaw, and the same remark applies to the exposure and suture of recent or old-standing fractures. In the latter we must first excise any soft tissues intervening between the bones and preventing healing, and then refresh the ends of the bone with the saw; in recent fractures it is unnecessary to do so. The Gigli wire saw will be found of great use in refreshing the bones; it has been already described and is illustrated in Fig. 38; the soft tissues should be retracted, but the bony stump should be separated as little as possible from its surroundings. The Gigli saw should not be bent at a sharp angle for fear of it breaking; the operator should rather hold the two handles as far as possible apart.

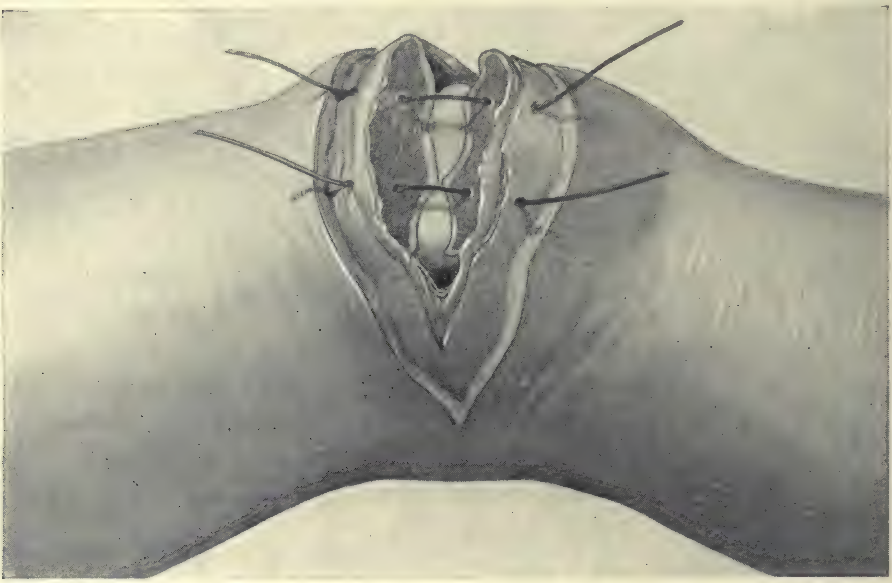

FIG. 150.—Wire suture of a fractured patella. The sutures do not project into the joint.

In addition to the saw pretty much the same set of instruments are used as are figured on pages 32 to 34 in the introduction to the resection of joints.

Broadly speaking, the technique of bone-suture consists in boring holes at the most suitable points and drawing wire sutures through them. In rarer instances (especially in oblique fractures) we are sometimes able to bring the fragments into good position, encircle them with a piece of wire and draw them firmly together. Aluminium-bronze wire gives the best results (silver wire is more pliable but breaks more readily). The fragments are first drawn and pressed into the desired position with the aid of stout single-toothed retractors. The wire is then carried through the holes, seized with a pair of flat forceps and twisted tight; the twisted wire is then snipped off, but some $\frac{2}{5}$ in. (1 cm.) is left buried in the tissues. There are many other methods for the suture of bone; we need only mention fixation with clamps, plates and screws, or the nailing with pins (*v.* p. 53 under resection of the knee).

The surgeon is often called upon to suture a broken olecranon or knee-cap. Suture of the patella is illustrated in Fig. 150.[1] The fracture runs right into the joint; note, however, that the wire is introduced so as not to project beyond the free articular surface. Expose the fracture with a transverse incision: this enables us to survey the torn extensor apparatus as well and to close it with catgut sutures. Fig. 151 shows the circular method of suturing the knee-cap with stout wire; it is applicable in stellate fractures and in those cases where one of the fragments is too small for direct suture to be employed or where the knee-cap has been smashed into small pieces.

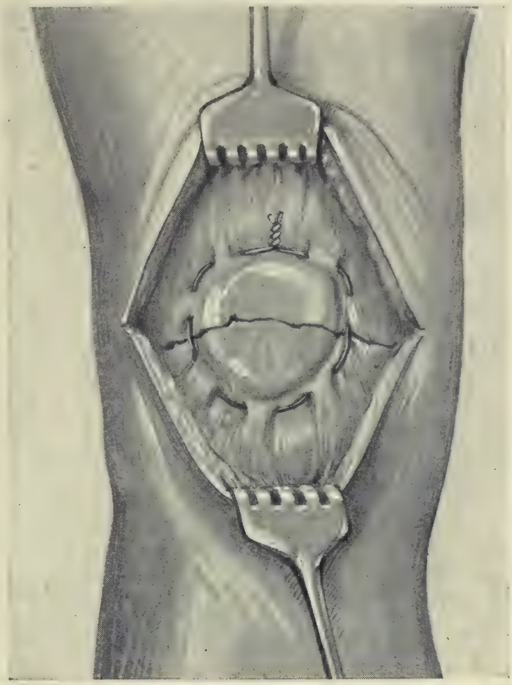

FIG. 151.—Reunion of the patella with a circular wire suture.

8. *Operation for Ingrowing Toe-nail.*

This is easily practised on the body. We have to deal with a lateral infolding of the great toe-nail, which keeps the surrounding tissues in a perpetual state of inflammation. The aim of the operation is to take away a large piece of the nail, and really the only way to put a stop to further "ingrowth" is to extirpate the root of the nail. A semilunar incision, as shown in Fig. 152, is quite serviceable. Commence with a linear incision that penetrates to bone and divides the root of the nail itself; add a curved incision, also down to bone. As regarded in cross section, a wedge piece is taken away, as shown in Fig. 153. After a clean excision the skin soon joins up to the remains of the nail.

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[1] The articular cartilage of the patella looks immediately into the joint.

The operation falls into two stages:—

(1) Turn out the torn edges of the aponeurosis that usually intervenes between the bony fragments.

(2) Coapt the bones.

If the first stage is neglected we may as well not operate at all.—TR.

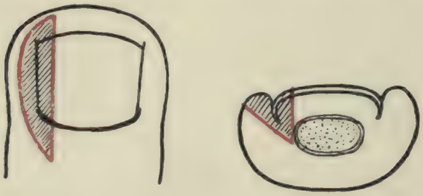
FIG. 152. FIG. 153.
Diagrams representing the operation for ingrowing toe-nail.

If we are dealing not with an ingrowing toe-nail but with inflammation below it, it may be necessary to remove the entire nail. Insert a pressure forceps (Pean's) under the middle of the projecting nail, and pressing deep, grasp the nail with it firmly; pull it out by twisting it to and fro with the forceps; this loosens the nail and enables it to be torn out, root and all. An even better way is to split the nail up the middle and then twist out each half by itself.

9. *Puncture of the Joints.*

The puncture of the great joints is becoming quite a frequent operation. It is employed for diagnostic purposes or for the excavation of fluid collections; the articular cavity can then be flushed out or solutions injected. There is no difficulty in puncturing a joint distended with fluid. In the case of the knee joint we use the trocar (Fig. 154), holding it as shown in Fig. 155; the trocar does not easily penetrate the skin, so it is well to begin by making a small skin puncture at the desired spot; then seize the instrument,

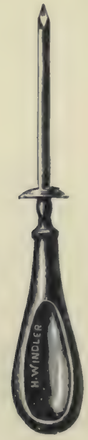

FIG. 154.—Straight trocar.

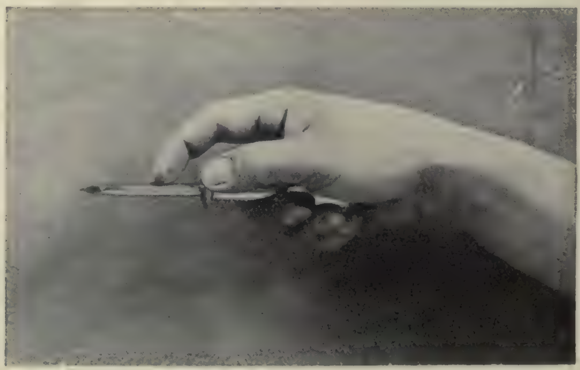
FIG. 155.—Way to hold trocar in puncturing.

resting the handle firmly in the hollow of the hand and directing the instrument with the forefinger. The trocar must not be bored slowly through the tissues but should be thrust forcibly into the joint; this prevents any undue pain being felt.

Diagnostic punctures are carried out with the aid of a syringe, armed with a sharp hollow needle. The same instrument is used for the injection of substances into the joints, *e.g.* iodoform in the case of tuberculosis.

The wrist joint should be punctured from the extensor aspect, between the tendons of the extensor pollicis longus and the extensor indicis. The line of the joint is found by drawing a line from the styloid process of the ulna to the styloid process of the radius. Large effusions can be drained by puncturing wherever they make themselves evident. The elbow joint may be punctured from the outside or behind. From the outside we thrust the needle immediately above the capitulum radii; the latter is easily felt by pronating and supinating the forearm. The needle enters the joint between the head of the radius and the lateral epicondyle. From behind we can pierce just above the tip of the olecranon, the joint should be held at an angle of 135°; our aim is to thrust the trocar in deep behind the olecranon till it enters the posterior recess of the capsule. The shoulder

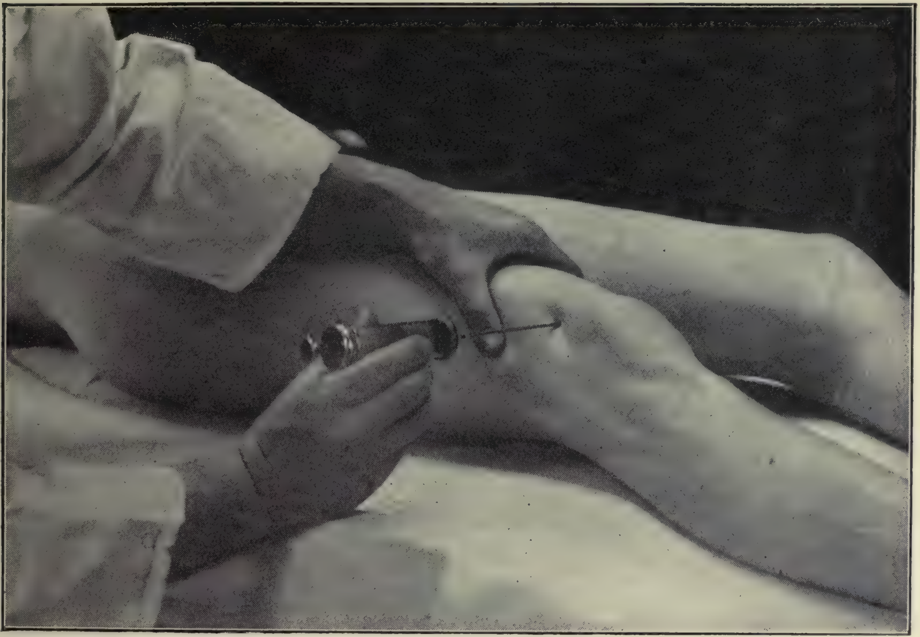

FIG. 156.—Puncture of the knee joint.

joint is punctured from the side, between the acromion and the head of the humerus. The needle should be pointed somewhat downwards: if it is pointed straight in we are apt to find ourselves not in the joint but in the subacromial bursa. Puncture of the shoulder is but rarely done.

Puncture of the ankle is also a rare operation. We thrust in from the front, either at the outer or at the inner side of the extensor tendons: at the inside $\frac{2}{5}$ in. (1 cm.), at the outside $\frac{4}{5}$ in. (2 cm.) above the tip of the malleolus; *i.e.* we penetrate between the trochlea tali and the tibia or fibula.

The knee joint should be punctured from the outside; the needle is thrust above the patella into the suprapatellar recess (cp. Fig. 59). The method of puncture is represented in Fig. 156. Like all the other punctures it is easy if there is much effusion in the joint. When the effusion is very slight or there is reason to believe that the superior recess is obliterated the needle should be introduced under the knee-cap from the side and near the lower margin of the bone.

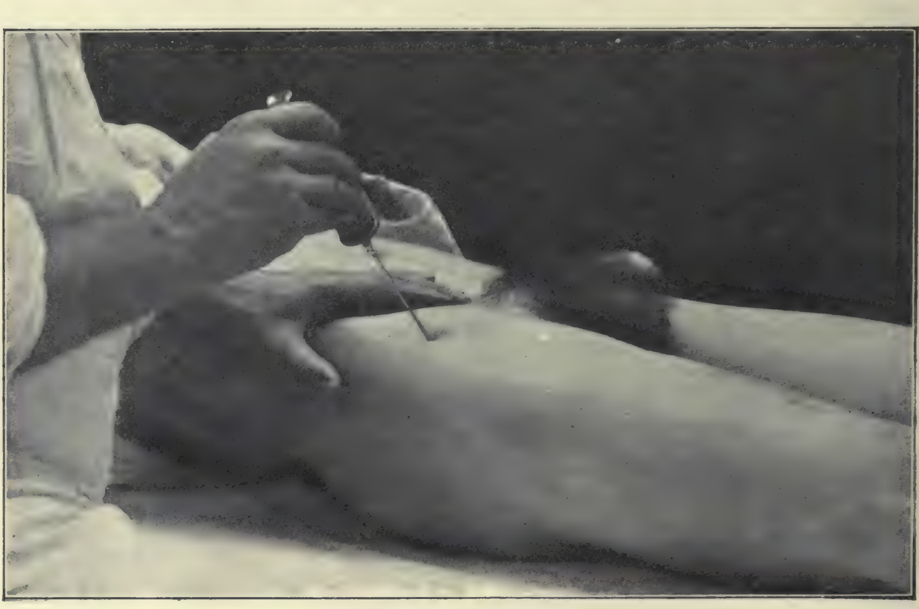

FIG. 157.—Puncture of the hip joint from the front.

Puncture of the hip joint is also of great importance. Determine the point at which the femoral artery is felt pulsating under Poupart's ligament and connect this point with the trochanter major. The mid point of this line may be taken as the site for puncture; it approximates roughly to the inner border of the sartorius muscle (*v.* Fig. 157); the needle should be directed only slightly inwards and it meets the joint at the upper border of the femoral neck, at the juncture of the head and neck. A second method is to adduct the leg and puncture from the outside just above the tip of the trochanter; the needle enters the upper part of the capsule.[1]

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[1] For Lumbar Puncture *vide* Appendix.

SECTION V

OPERATIONS ON HEAD AND NECK

A. Operations on the Cranium

Introduction.—Trepanning in General

Operations on the bony vault of the skull are performed sometimes on account of disease or injury to the bone, and sometimes for intracranial affections.

The bony cranium is composed of several layers: first, the external table, under this the richly vascular diploe, and deepest of all the vitreous table, a thin dense layer of bone that cracks very easily on injury. The soft tissues on the outside consist of skin and coarse connective tissue, below this comes the occipito-frontalis aponeurosis with its associated muscles and then the periosteum. The aponeurosis is freely movable on the periosteum; the latter adheres pretty closely to the bone. On the inside periosteum and dura mater are blended to form a single layer.

When the skull has to be opened in cases of comminution or disease of the bone, the simplest method of trephining is chosen, *i.e.* complete removal of a limited part of the bony roof. For the sake of practice a few comminutions can be effected with a hammer. Make a thorough division of the soft parts and remove all the diseased tissues with hammer and chisel. Extra care should be taken to remove any overhanging edges of bone, as they interfere with the elevation of any fragments that may have penetrated into the brain. Excellent results are obtained by the use either of the rongeur (Luer's gouge forceps, Fig. 40) or of bone forceps specially designed for cranial work (*v.* Figs. 158 and 159). These instruments are used only for nipping off small pieces at a time; the rongeur should always be twisted outwards in order to preserve the brain intact. Chiselling of the skull is done by means of an ordinary joiner's chisel (with wooden handle) and a wooden mallet. The beginner should make a point of practising the use of the chisel for trephining purposes in order to handle the instrument with certainty and avoid any chance of it slipping. The art of chiselling is a most important one in surgical practice.

When an opening had to be made in the skull through sound bone, *e.g.* for evacuating a haematoma or abscess or for ligaturing the middle meningeal artery, surgeons were wont to employ the hand trephine (Fig. 160), from which the term *trephining* is derived. This instrument was a hollow cylinder furnished with sawing teeth ; it bored a hole of uniform size in the bone and was applied in the following way : The periosteum having been raised and the bone exposed, the trephine was applied to the bone with its central point projecting. It was then rotated till a circular groove was produced, the point was withdrawn and the bone gradually sawn through with the trephine. The platelet of bone was then extracted by a specially designed instrument. The use of the hand trephine has been abandoned.

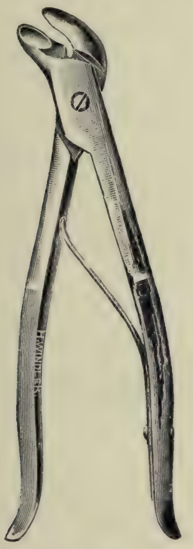

FIG. 158.

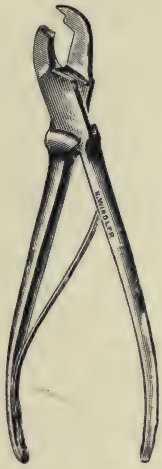

FIG. 159.

Rongeur forceps for the skull.

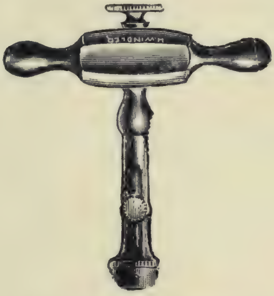

FIG. 160.—Hand trephine.

In addition to chisel trephining modern cranial surgery offers us a rich selection of effectual methods. The chief desideratum in all of them is a technique that will be not only rapid but calculated to avoid injury to the dura and concussion to the skull, results that are possible from blows with a chisel.

An excellent method is to employ Dahlgren's rongeur forceps (Fig. 161). Make a skin incision and bore a large hole down to the dura, or chisel out an opening the size of a bean with a narrow gouge. Then introduce the hook of the instrument below the edge of the bone and break it away bit by bit till a circular path has been traced through the bone right round the focus of disease. The lower side of the hook is rounded off and instead of injuring the dura it separates it gradually off the bone.

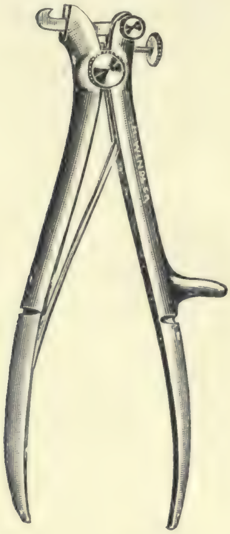

FIG. 161.—Dahlgren's trephining forceps for the skull.

Gigli's saw offers another method. Fig. 162 shows how it can safely be employed for opening the skull. Holes are bored along the intended line of division $1\frac{1}{2}$ in.–2 in. (4–5 cm.) apart, with a broad borer (Fig. 163) or a bur (Fig. 164). A thread is then passed on an aural probe between the bone and the dura, and the Gigli wire saw drawn after it. A plate of bone is then gradually sawn out, the bone being divided obliquely so that more of the external table is removed than of the internal.

Trephining technique has become really elegant and rapid since the introduction of electrical borers. A strong current is advisable. The simplest method of application is to make a small puncture wound in the scalp and drill a small hole in the cranium for diagnostic purposes; this might be termed a subcutaneous puncture. For boring larger holes, Doyen's electrically driven burs (Fig. 164) are in general use. A preliminary incision is required to expose the bony cranium; if the boring is done slowly and the depth of the wound frequently tested it is quite easy to expose the dura without risk of

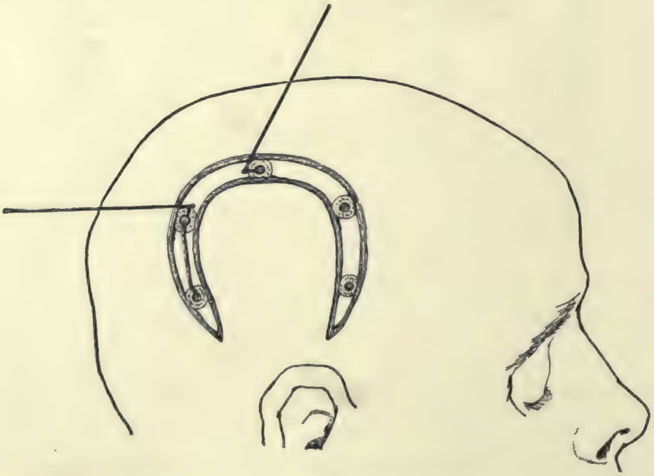

FIG. 162.—Trephining with Gigli's wire saw.

suddenly puncturing the membranes. Doyen's bur can be used for gradually boring away large pieces.

Small rotating circular saws can also be employed. Sudeck's bur marked an important advance. It is a small, rapidly rotating borer with a spiral thread and a small head at its end to protect the dura. Begin by boring a hole in the skull with an ordinary instrument; then introduce the bur vertically to the skull, and with its head resting but not pressing on the dura force it laterally through the bones. All these boring instruments must be taken to pieces at intervals and cleared of bone dust.

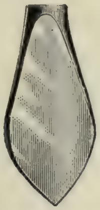
FIG. 163.—Broad borer for the skull.

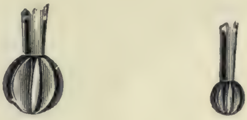
FIG. 164.—Cylindrical burs for perforating the skull.

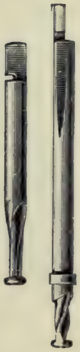
FIG. 165.—Sudeck's trephining drill.

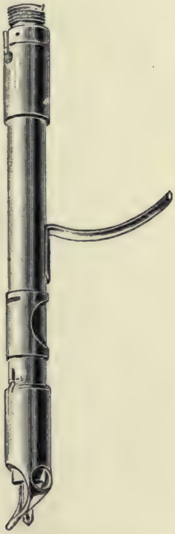
FIG. 166.—Borchardt's trephining drill.

The most modern bur is that of Borchardt (*v.* Fig. 166). It consists of a powerful obliquely-set borer; a bridle prevents it penetrating too deep. It is only used for the external table and the diploe; a few blows with the chisel suffice to divide the rest of the bone. The instrument works splendidly.

Modern technique has given us a whole series of instruments to choose from. The ones we chiefly employ for opening the skull are the chisel, Gigli's saw, and Dahlgren's rongeur.

The old method was to remove a piece of bone completely. Modern cranial surgery is dominated by the osteoplastic, temporary resection method, which we owe to Wagner (Fig. 167). His operation is as follows: Make a bold incision down to the bone and raise a horseshoe flap of the soft tissues: the periosteum is pushed to the side in the line of the incision, but apart from this the flap is at first left *in situ*. The base of the flap must not be too narrow, or else its nutrition will suffer; nevertheless the circulation in the scalp is so good that even the edges of the

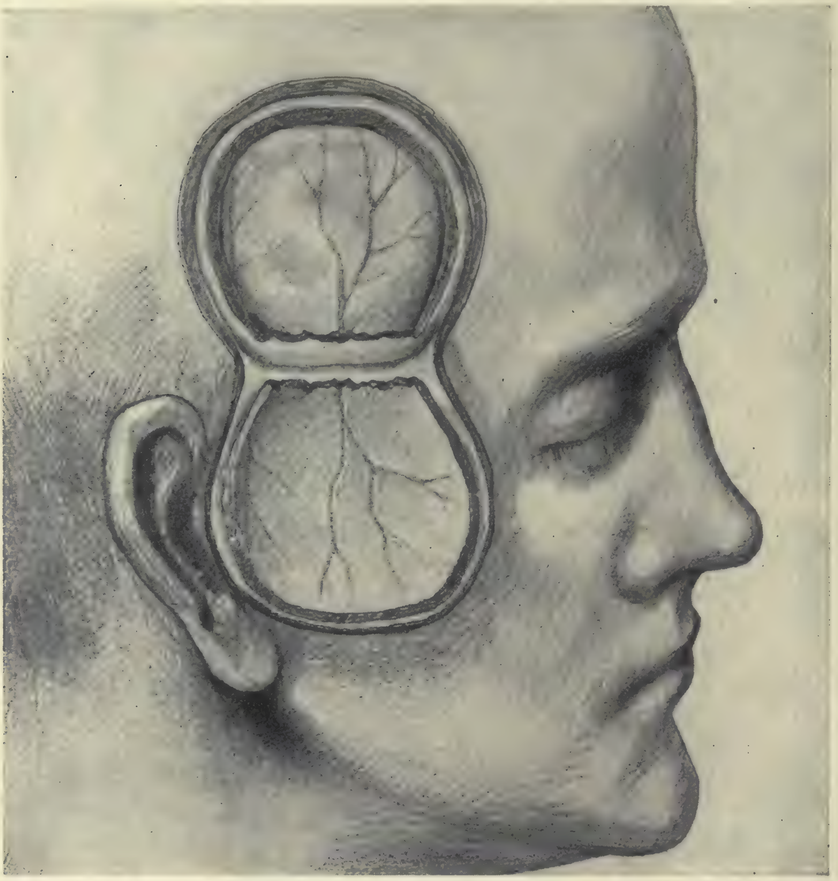

Fig. 167.—Osteoplastic trephining (Wagner).

flap retain their vitality, provided the bridge of tissue is not less than half the maximum breadth of the flap. One should be careful, however, to plan the flap with its base downwards, as the arteries run from below ; special care should be exercised to preserve the main division of the superficial temporal artery in lateral temporal flaps. If muscle is encountered in cutting into the soft tissues, try to separate in the line of the fibres (temporal muscle). Employ now one of the above described methods, *e.g.* Dahlgren's rongeur, and open the skull along three-quarters of a circle, *i.e.* corresponding to the extent of the skin incision. But the window in the bone should always be smaller than the flap in the soft tissues, for this prevents the osseous and cutaneous scars from coinciding and enables one to enlarge the trephine opening without the need of an additional skin incision. Introduce next a narrow straight chisel under the base of the flap and chisel into the bridge of bone from either side. The flap of skin, periosteum and bone can then easily be raised and turned down by means of an elevator, as shown in Fig. 167. As a rule the bone comes away at once from the dura and meningeal vessels. The surgeon then carries out his operation on the bone. Before the osteoplastic flap is folded back, however, it is well to take bone forceps and nibble away the sharp edges of the bone at the point where it was broken away. This makes it easy to fit the flap into place, its fixation and subsequent healing being secured entirely by a close suture of the soft tissues of the scalp.

This temporary resection is one of the most important and frequently practised operations in modern surgery. Horsley does it in two stages. Having arrested the hæmorrhage, he turns back the osteoplastic flap at once and closes the wound with a few sutures. After an interval of from eight to fourteen days he has no trouble in reopening it and performing the real brain operation at a second sitting. To operate in the first stage might impose too great a strain on the patient.

The modern surgeon must be ready to resort to osteoplastic closure of cranial defects, with a view to affording additional protection to the underlying pulsating brain. In recent fractures of the skull an excellent method is to expose the part affected, extract the bony splinters from the depths of the wound and arrange them in the form of a mosaic over the defect.[1] The pieces should either be washed free of blood and tissue debris or boiled ; healing may then be confidently awaited. In some methods the loss of tissue is made good by the introduction of foreign bodies, in others a free transplantation of bone is made from another part of the body. The Müller-König operation, however, is entitled to first place. In this method

[1] This is called the "tesselated pavement" method.—TR.

a pedunculated flap is fashioned from the neighbouring tissues, and a flat portion of the outer table of the skull is chiselled away along with it: the flap is then grafted over the cranial defect. It is practised in the following way: form a soft tissue flap with its pedicle downwards at the place you assume the defect to exist, and free it completely (cp. in Fig. 168); create a gap in the exposed part of the skull equal to a two-shilling piece (Fig. 168*b*). Then set to work to cover this defect. For this purpose form another flap right alongside the first, but with its pedicle upwards (Fig. 168*c*), and without freeing it chisel away a portion of the external table to correspond with the hole *b*; this is left adherent to the flap, which is gradually loosened up as the chiselling proceeds. It is but seldom that we secure a complete disc of bone in the flap: at best it is composed of several fragments. Rotate the pedicle of the osteoplastic flap *c*, and insert the graft into the defect and suture it in position. The fresh defect can be almost completely closed by exchanging the first flap *a* with its neighbour (*v.* Fig. 169). The method is interesting and its practice on the subject extremely advisable.

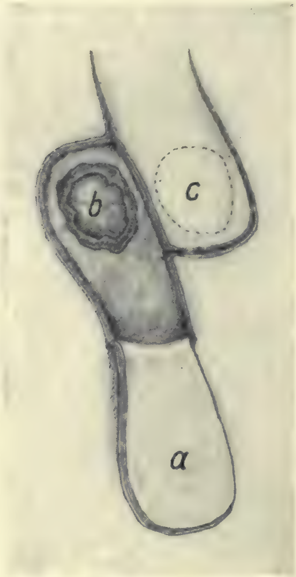

Fig. 168.—Müller-König osteoplastic flap for covering cranial defects; I. Stage.

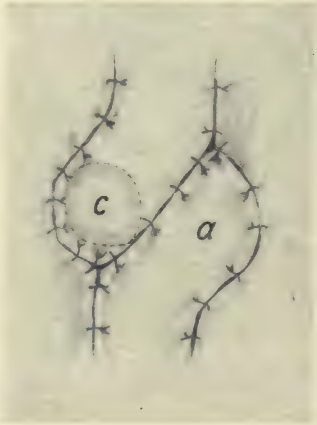

Fig. 169.—Müller-König osteoplastic flap for covering cranial defects; II. Stage.

Bloodless methods are not practised on the subject. We mention them, however, for the sake of completeness, as they are of prime importance in operative work. Haemorrhage from the cut surface is very free in every part of the scalp but can be lessened by initial compression. The only way to control the main vessels is by subcutaneous ligation; simple ligatures slip off. Many vessels do not stop bleeding until after the suture of the skin. Bloodless operations can be performed on the cranial vault by applying a band round forehead and occiput. This controls all bleeding from the vessels of the scalp. Heidenhain taught us further that it was possible to control bleeding from any part of the scalp before the skin incision by introducing a strong silk suture and ligaturing the tissues tightly *en masse* before making the skin incision.

1. *Exposure of the Cerebrum, the Fissure of Rolando, and the middle Meningeal Artery.* (Topography.)

The methods above described enable us to trephine the surface of the cerebrum at any point we like. It must here be noted that the great venous sinuses run in the dura mater: the seat of disease will determine which one is to be specially avoided; but with care it is quite possible to trephine over a sinus when once its wall has been pushed off the bone. Large vessels, and especially arteries, are also found running on the surface of the dura; the middle meningeal artery is the most important of these and if torn in injuries to the skull it may give rise to large extravasations of blood. When this happens it is to be exposed and ligatured as near as possible to its main stem. In order to reach the brain itself, the dura must be divided in the trephine opening; lift up a fold of it with a pair of fine surgical forceps and open it with delicate scissors, which should be guarded by a protecting head. Once a fine hole has been made in the dura it is easy to lift up the edges and slit it up further, guided by the guarded arm of the scissors. The success of the operation depends on preserving the brain and the thin-walled vessels of the pia from injury.

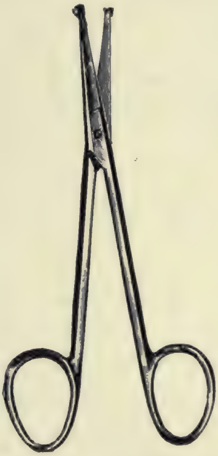

FIG. 170.—Fine guarded scissors for the dura.

For the exposure of definite parts of the surface we must be able to project them on the surface of the head. A horseshoe flap is then made to correspond. There are a large number of projection methods, and each operator chooses the one that suits him best; to carry them all in one's head is confusing. Following the practice of Bier's clinic, we advise the reader to get up Krönlein's scheme (Figs. 171 and 172). It is represented here in two diagrams that adhere closely to Krönlein's original plan. Its main lines should be drawn upon the skin of the scalp with a coloured pencil prior to the trephining. Our aim is to project the fissure of Rolando on the surface, for in front of it there lies the anterior Rolandic gyrus (*Gyrus praecentralis*), containing the principal motor centres. We also wish to establish the course of the fissure of Sylvius and the chief points for ligaturing the middle meningeal artery.

Krönlein's rules are as follows:—

1. Draw a horizontal line between the inferior orbital margin and the external auditory meatus (lower horizontal).
2. Draw a line parallel to the base line through the upper margin of the orbit (upper horizontal).
3. Erect a vertical from the middle of the zygoma at the point A (Fig. 171) (anterior vertical).

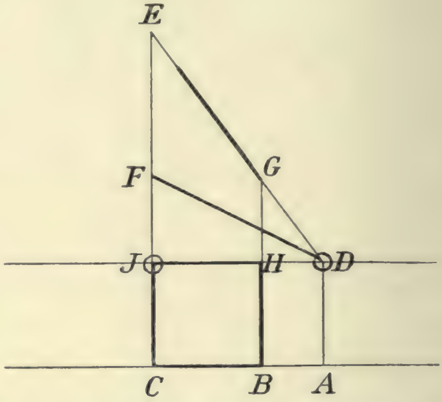

Fig. 171.—Krönlein's scheme for projecting the more important cerebral areas on the surface of the cranium.

4. Erect a vertical line to correspond to the temporo-sphenoidal joint at the point B (middle vertical).
5. Erect a vertical line at the posterior border of the mastoid process at the point C, and carry it up to the sagittal line on the cranial vault (posterior vertical).
6. Connect the point at which the upper horizontal meets the anterior vertical (the point D) with the point E (the place where the posterior vertical crosses the sagittal line). This gives the oblique line of Rolando.
7. On bisecting the angle between the Rolandic line and the upper horizontal line you get the line DF, which may be termed the "Sylvian line." Add the points GHJ to the diagram in Fig. 171, and one can draw the following conclusions (compare Fig. 172):—

The Sylvian fissure corresponds to the oblique DF.

The fissure of Rolando (central sulcus) begins about the point G, and ascends obliquely to about the point E.[1]

D and J lie on the upper horizontal line, and are Krönlein's main points in trephining for the middle meningeal artery.

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[1] The point E is about ½ in. behind the centre point of a sagittal line drawn from nasion to inion.—Tr.

The quadrangle HJCB delimits v. Bergmann's area in resection of the skull for temporo-sphenoidal abscesses (in otitis media).

These are our rules for osteoplastic exposure of the different regions. A previous figure (Fig. 167) represents the exposure of the middle meningeal artery with the dura intact. The osteoplastic exposure of the fissure of Rolando is given in Fig. 173, with the dura incised crucially. This operation does well for practice on the subject. On the completion of the operation the dura is again closed with a fine continuous catgut suture, provided conditions are not such as to force us to resect it and leave the brain uncovered.

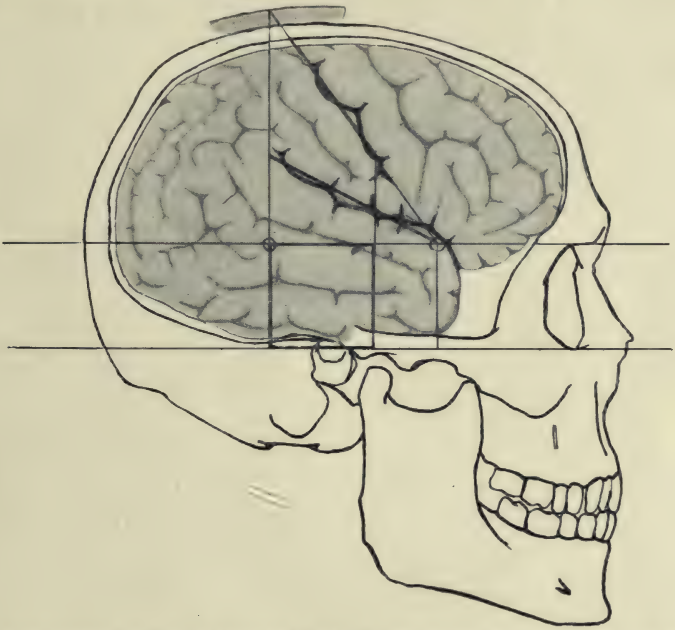

FIG. 172.—Krönlein's scheme. Method of finding the fissure of Sylvius, the fissure of Rolando and Krönlein's points for the middle meningeal artery.

It is essential to get up Krönlein's or some other good scheme. Without the help of a scheme we shall fail in many cases. Modern brain surgery has certainly made great advances in operative technique and given us confidence, and we do not hesitate to make large osteoplastic flaps. Indeed, we now make a point of excising any suspicious focus with a good margin to spare. Doyen goes furthest in this respect with his hemi-craniectomy.

2. *Exposure of the Cerebellum.*

The exposure of the cerebellum is in contrast to that of the cerebrum. The latter is generally carried out by the osteoplastic method, but in the case of the cerebellum we turn down a flap of skin and periosteum and make no attempt to preserve the bone (which is not so thick at this point): the soft tissues of the neck are thick and afford ample protection to the brain. Place the body in the prone position, insert a cushion under the chest and flex the head over it so as to render the occiput easy of access. In the living subject the first step is to control the operation area by means of Heidenhain's tissue ligation. Then carry a curved incision from the one mastoid process to the other, as shown in Fig. 174, crossing the middle line a little above the external occipital protuberance; the base of the flap lies in the line

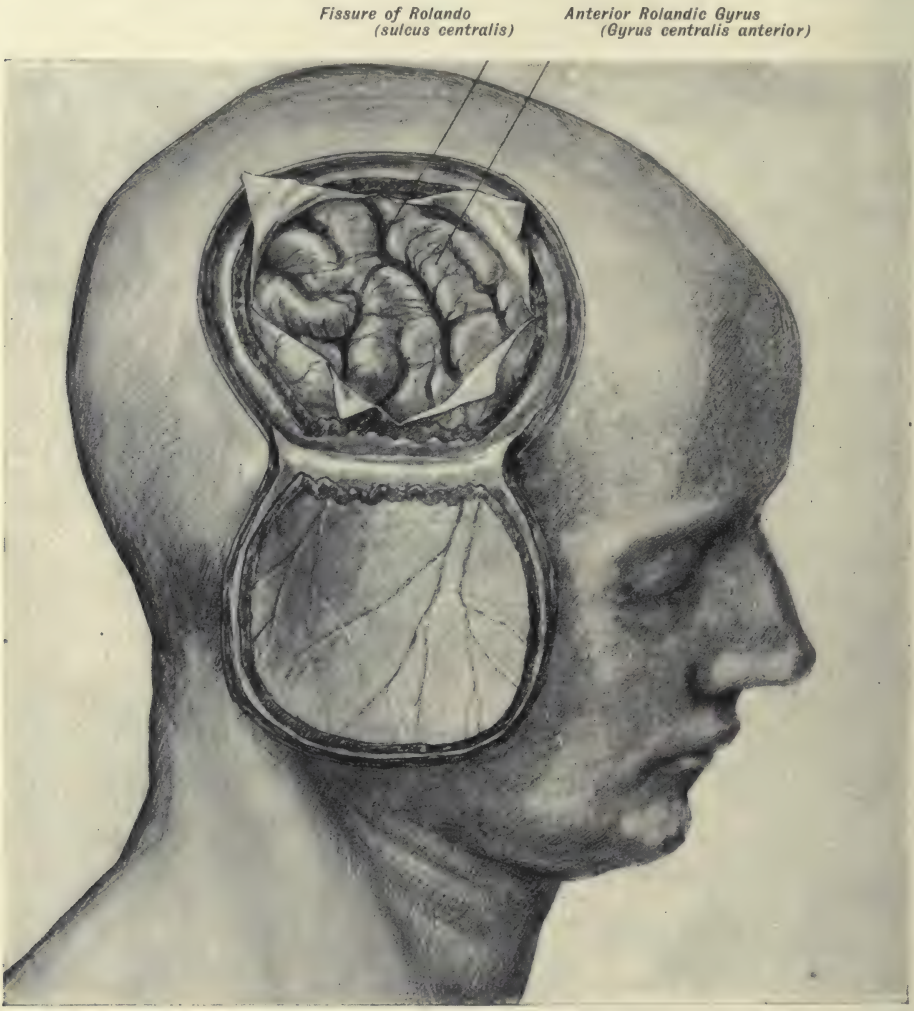

FIG. 173.—Osteoplastic exposure of the central sulcus (Fissure of Rolando).

connecting the tips of the mastoid processes; the two ends of the incision should not extend further forwards than the posterior border of the mastoid process; in this way we can avoid any hæmorrhage from the large emissary veins (*Foramina mastoidea*). Next insert strong retractors into the flap and shell the periosteum and flap downwards; this can be done partly with the elevator, but the cervical muscles running to the occiput will require to be separated away with transverse sweeps of the knife. The hæmorrhage is copious if Heidenhain's method is not employed; it fails, however, to prevent free bleeding from the emissary veins of the skull, while multiple mastoid veins are not at all uncommon and always give rise to bleeding when torn: their position should be determined even in the subject. In the living subject they may be stopped with wax. Continue to separate the soft tissues till the outer surface of the occiput is exposed almost down to the foramen magnum. The next step is to open the skull. This presupposes a thorough acquaintance with the course of the venous sinuses in the dura mater; we may, if we like, trephine the skull over a sinus, but the dura must first be scaled from off the internal table. As a general rule we go in between the sinuses, their course can be seen in Fig. 175. The two large lateral sinuses are seen in the base of the skull: they are the largest vessels in the dura mater and are connected at the torcular Herophili; the sagittal sinus joins the torcular opposite the internal occipital protuberance. The occipital sinus is smaller and runs from the torcular down to the foramen magnum: it then forks and runs forward round the edges of the foramen to unite with

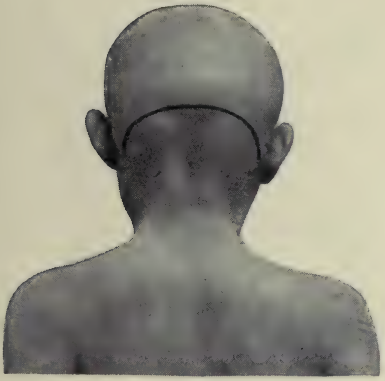

FIG. 174.—Incision for bilateral exposure of the cerebellum.

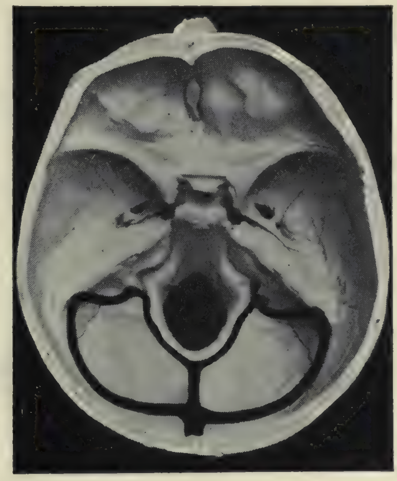

FIG. 175.—Diagram of the dural sinuses in the posterior fossa of the skull.

the lateral sinus: like the latter it pours its blood through the jugular foramen into the internal jugular vein. Next take a middle-sized gouge in hand and open into the posterior fossa on one side; the wall of the skull is very thin at this point. Chisel cautiously with the cutting edge resting flat on the bone, till you espy the dura; then proceed with bent rongeur forceps to remove the bone over the area of a crown piece, being careful not to injure the dura in the process. Perform a similar exposure on the other side of the cerebellum, so that both hemispheres are now ready to be palpated and punctured. The opening in the bone can be enlarged in any direction, even up to beyond the transverse sinus; the sinus is not opened but is

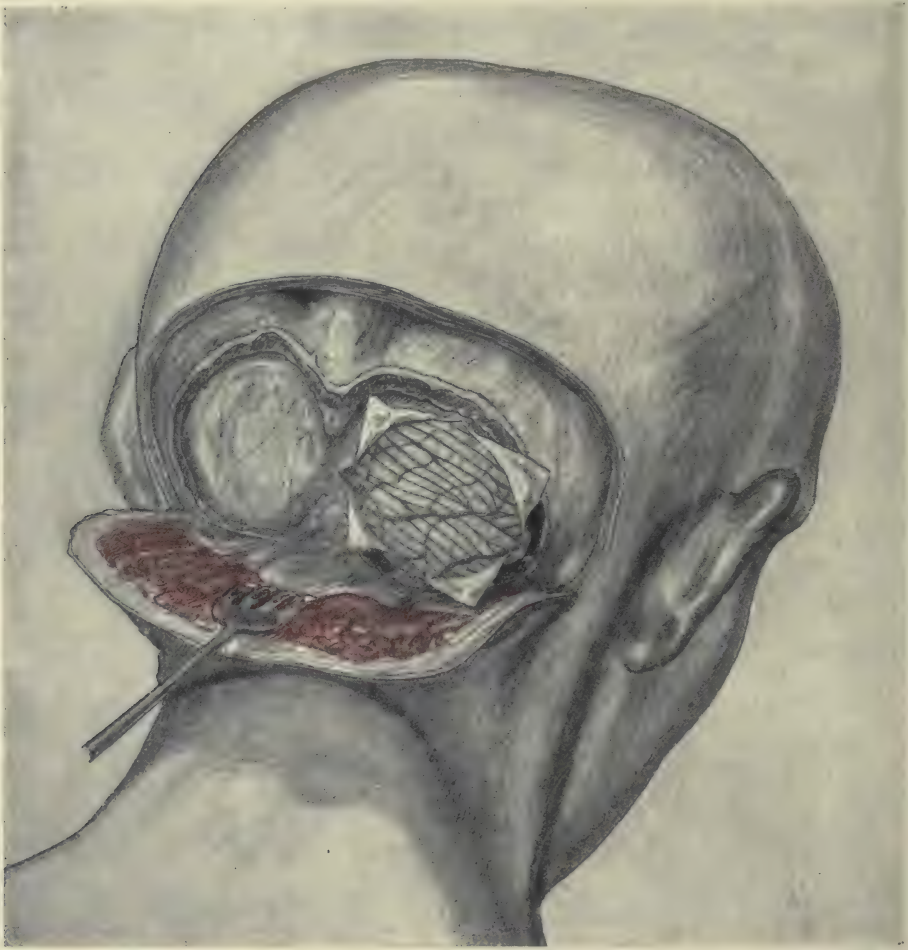

FIG. 176.—Trephining to expose the two cerebellar hemispheres. The dura has been opened on the right side.

displaced along with the dura. One can also nip away the median bridge of bone which at first was left intact, but great care must be taken to preserve the underlying occipital sinus. Fig. 176 illustrates the way in which the dura is divided over one of the hemispheres but with the occipital sinus not yet ligatured. The dura must be opened before we are able to decide the extent to which the bone must be removed for a complete view of the whole hemisphere. The one half of the cerebellum may then be raised on a spatula and displaced to the side: the palpating finger is thus enabled to explore the space between cerebellum and pons. If it has been already determined to open the dura on both sides, a broad flap of dura should be reflected downwards and the occipital sinus doubly ligatured and divided. For a thorough exploration of the cerebellum the hemispheres may be incised. There is always considerable difficulty in resuturing the dura, for the cerebellum has a strong tendency to prolapse; some surgeons have therefore recommended that small pieces of the organ should be cut away; but we usually content ourselves with drawing the dura together with a few sutures, replacing the flap of soft tissues, leaving openings for lateral drainage and stitching up the scalp.

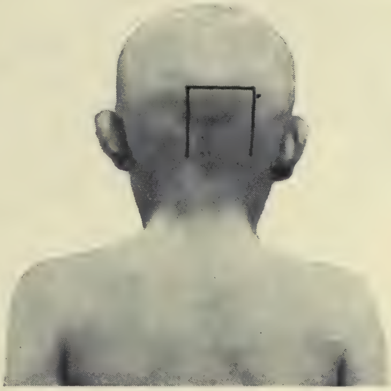

FIG. 177.—Flap incision for unilateral exposure of the cerebellum.

An even fuller exposure of the posterior fossa of the skull can be secured by means of a large osteoplastic flap, the pedicle of which should run well into the neck; but this operation entails considerable shock to the patient. The cerebellum is often attacked in two stages, *i.e.* we first expose the dura and suture up the wound provisionally and then complete the operation after an interval of some days.

In a few instances the site of the lesion may be localized prior to operation: a unilateral flap is then sufficient, as shown in Fig. 177. The flap method is again the best; the flap is rectangular, extending to $\frac{3}{4}$ in. (2 cm.) above the external occipital protuberance and resting on a line connecting the tips of the mastoid processes; the inner edge of the flap oversteps the mid line and this allows of greater freedom of action to the operator. The rest of the operation agrees with the description of bilateral exposure.

3. *Trephining of the Mastoid Process and Radical Operation in Middle Ear Disease.*

The operations that come under the above heading will not be discussed from the specialist's point of view. We shall not attempt to multiply details, but shall include merely the sum and substance of what is usually practised on the subject, *i.e.* enough to prevent the operator from injuring the main structures.

In those cases in which puncture of the membrana tympani is not sufficient to allow of the free egress of the pus, and the epitympanic recess, the mastoid antrum and the mastoid cells are all infiltrated, we must open into the mastoid process by a posterior auricular incision. This forestalls a double danger, the penetration of the pus through the tegmen tympani into the middle fossa of the skull (meningitis, cerebral abscess) and the invasion of the lateral sinus (thrombophlebitis and pyaemia). Expose the mastoid process by means of the skin incision shown in Fig. 178*a*; it runs parallel to the attachment of the ear cartilage and $\frac{2}{5}$ in. (1 cm.) behind it, and is carried right down to the bone. Then shell off the periosteum in front and behind, and retract the tissues firmly apart. This exposes the posterior bony margin of the external auditory meatus; at the junction of its posterior and upper border we see the delicate suprameatal spine, a thorn-like process, and still higher the better marked suprameatal crest, the continuation of the posterior root of the zygoma (cp. Fig. 179).

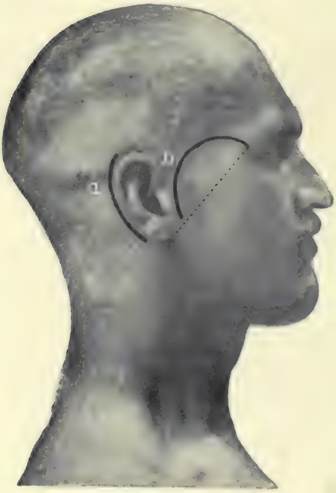

FIG. 178.—Incisions (*a*) for the exposure of the mastoid process; (*b*) for the extirpation of the Gasserian ganglion.

In order to open the mastoid cells we take a small gouge and chisel away the outer wall of the mastoid process almost as far as its border; we open up each cell thoroughly and scrape out the mucous membrane, but if it is proposed to penetrate below the cortical layers we must operate within more circumscribed limits, for there are several structures liable to injury in the neighbourhood. We divide the mastoid process into four parts, as seen in Fig. 179; the anterior and upper quadrant is our guide to the deep mastoid cells and mastoid antrum.[1]

The operation runs as follows: Take a fine gouge (Fig. 181) and make an opening of not more than half an inch. In an upward direction it should not extend above the supramastoid crest. The rule is to proceed parallel to the posterior wall of the auditory canal, *i.e.* not directly inwards but rather forwards and a little upwards. This enables us to avoid the three great dangers that here threaten: downwards there is the risk of destroying

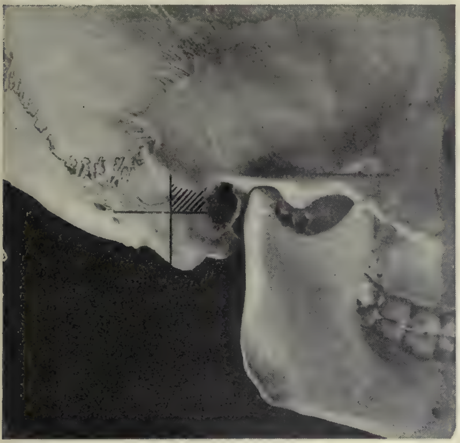

FIG. 179.—Division of the mastoid process into four quadrants. The typical site for chiselling lies in the upper and anterior quadrant.

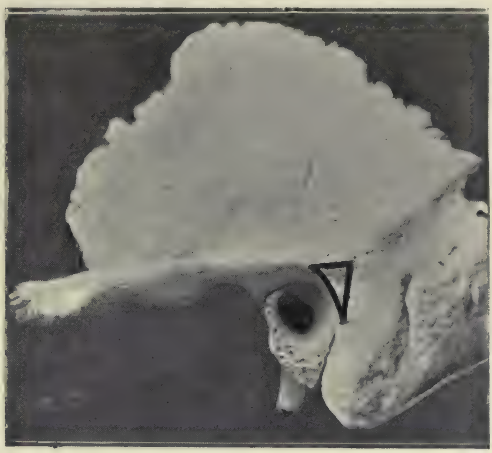

FIG. 180.—The suprameatal triangle.—TR.

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[1] The British and American plan for exposing the antrum is by Macewen's suprameatal triangle. This is formed:—

(1) by the postero-superior segment of the bony external meatus, in front;
(2) by the posterior root of the zygoma, above;
(3) by a line from the posterior border of the bony external meatus, behind: this line is drawn tangential to (1) and at right angles to (2): compare Fig. 180.

It is along and in front of this third line that the surgeon should advance to enter the antrum.

The feature of the method is that it lays stress firstly, on the need of adhering to the posterior wall of the bony canal, and secondly, on the inadvisability of transgressing the supramastoid crest. We must not plunge into the lateral sinus; its position varies; it usually extends to about a third of an inch from the posterior wall of the bony meatus, but sometimes it even projects forwards between the antrum and the external surface of the mastoid process; the right sigmoid sinus is usually larger than the left. We must not plunge into the brain; the supramastoid crest lies as a rule immediately below the level of the floor of the middle fossa: I have seen a case, however, where the temporo-sphenoidal lobe reached a quarter of an inch below the level of the crest.

Cerebellar abscess is not so common as cerebral abscess. The cerebellum can be exposed by opening one and a half inches behind the centre of the external auditory meatus and half an inch below it. Try to preserve the mastoid vein.—TR.

the facial nerve, backwards we come upon the lateral sinus, penetrating upwards we might break through the tegmen tympani and the dura into the brain. Chisel on carefully in this way till you open up the mastoid cells and the mastoid antrum. This completes the operation, for of course the skin is left unsutured. But when we are obliged to enter the middle ear itself the procedure becomes considerably more difficult and onerous; the chiselled opening has then to be laid into communication with the epitympanic recess and the tympanum. Begin by completely separating away the cartilage and cuticle from the bony part of the auditory canal and incise the lining membrane close in front of the membrana tympani so as to bring the membrane into view. Then pass a silk thread through the lining of the canal, pull the whole ear firmly forwards and gradually chisel away the postero-superior wall of the osseous canal. At this stage introduce a probe into the mastoid antrum through the aditus ad antrum, so as to prevent the occurrence of any injury to the facial nerve and external semicircular canals, both of which are placed at the postero-inferior border of the aditus.[1] A spur from the postero-inferior wall of the auditory meatus should be retained. With cautious strokes of the chisel break down the osseous bridge that still intervenes between the original opening and the external osseous meatus, and by advancing from behind and above the membrana tympani gradually open up the tympanic cavity and the epitympanic recess till they form part of the common opening. This secures complete excavation of the pus and allows the ossicles to be removed if necessary.

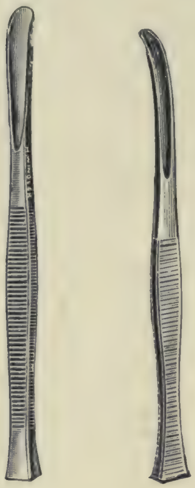
FIG. 181.—Small gouge-chisels for exposure of the antrum.

We must be constantly on the alert during the operation to avoid injuring the various structures mentioned, especially the facial nerve. It may be necessary, however, to continue trephining as far as the dura; in this case we must carefully chisel away the tegmen tympani, a thin scale of bone covering in the tympanum; the suspected abscess may lie either outside or inside the dura or in the substance of the temporo-sphenoidal lobe itself. If symptoms set in pointing to an infection or thrombosis of the lateral sinus it is to be exposed in the sigmoid sulcus. The sigmoid sinus is found by continuing to chisel backwards into the mastoid process, advancing very cautiously till the bluish wall of the sinus appears in the depth of the wound. The sinus may be punctured, or it may even be cleared out, as in cases of thrombosis or suppuration. For larger temporo-sphenoidal or cerebellar abscesses there exist special points for trephining, behind the mastoid process or above the supramastoid crest.

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[1] The facial nerve is enclosed in a canal of specially compact bone. After passing horizontally back immediately below and parallel to the external semicircular canal it turns vertically downwards. The commencement of the vertical part lies in relation to the inner wall of the aditus.—TR.

Although we have only sketched the outlines for operating on the mastoid, it should be mentioned that in chronic cases various plastic methods are employed for covering in the large cavity in the bone.

4. *Extirpation of the Gasserian Ganglion.*

Another typical opening of the bony cranium is done for the exposure and extirpation of the Gasserian ganglion (*G.* semilunare) in the worst forms of trigeminal neuralgia. It is a difficult operation, but it is easy to perform on the dead subject. It was perfected by Krause and has since undergone a series of modifications, of which Lexer's is the most important. Krause's original directions led to purely osteoplastic operations being done, *i.e.* the surgeon fashioned a temporal flap with its base below and turned it downwards: it contained the external soft parts and a disc of bone from the temporal region. This osteoplastic method is not essential, for the opening in the bone need be only a small one and it is sufficiently protected even without any covering of bone, being hidden behind the zygoma and the temporal muscle. The chief means of securing ready access to the part is to open the base of the bony cranium up to the foramen spinosum and the foramen ovale. We shall find it of the utmost advantage to follow Lexer's directions and to divide the zygoma early in two places and turn it down along with the flap.

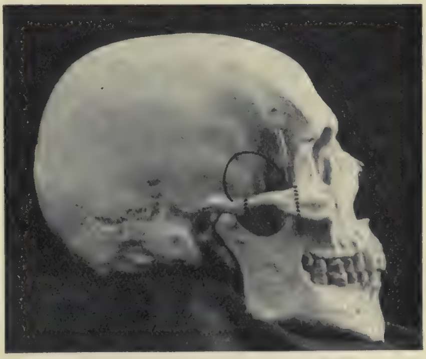

FIG. 182.—Lines for dividing the bone in extirpation of the Gasserian ganglion. The dotted lines indicate where the zygoma is usually resected, the other line represents the trephining of the temporal bone. (Krause. Lexer.)

The operation itself runs as follows: Place the subject in the half-sitting posture. Cut firmly down to the bone and fashion a soft tissue flap as shown in Fig. 178*b*. Its terminals lie on one and the same line, a line connecting the lobule of the ear with the eyebrow; in this way the more important branches of the facial nerve can be avoided. Then raise the soft tissues and periosteum from the bone, taking care to separate away every bit of muscle, and turn the flap downwards in one piece. The zygoma lies under the skin incision and is divided at two points with chisel or wire saw, as shown in Fig. 182. This makes it easy to separate the soft tissues as far down as the infratemporal crest, flap and zygoma being reflected downwards together. Next chisel an opening in the floor of the temporal fossa and after exposing the dura remove a portion of the cranial wall in this region biting it away piece by piece with rongeur forceps (Luer's): compare Fig. 182.

Continue to bite away pieces of the bone and to press back the dura till the base of the skull is reached at the infratemporal crest: work on in the direction of the foramen spinosum, following the course of the middle meningeal artery as it runs in the dura. This artery has now to be doubly ligatured with a delicate aneurism needle as it ascends through the foramen spinosum between the bone and the dura: it is then divided (it is not always necessary to ligature it). Work on in front of the middle meningeal and bite away little bits of the base of the skull till the foramen ovale is reached; this brings into view the third division of the trigeminal, which leaves the base of the skull by passing vertically down through the foramen ovale. During the exposure of the nerve the brain is to be elevated with a broad spatula. We then surround the third division of the fifth with a stout silk suture, thus enabling us to drag the Gasserian ganglion out of its extradural bed. Continue carefully to push back the dura at the anterior aspect of the ganglion till the second and third divisions are exposed. The second lies above the third and pursues a forward course; it should also be encircled with a silk thread. Lastly, expose the first division from below

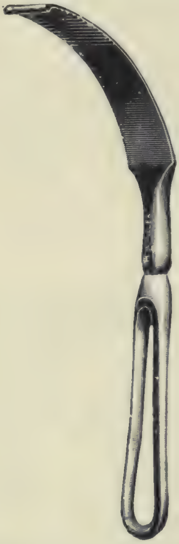

FIG. 183.—Brain spatula for the temporo-sphenoidal lobe in the extirpation of the Gasserian ganglion.

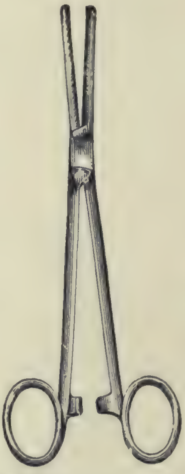

FIG. 184.—Thiersch's nerve forceps.

and free the ganglion away from the dura: copious hæmorrhage always occurs at this stage.

When the ganglion is far enough exposed for it to be grasped with a pair of Thiersch's forceps (Fig. 184), the third and second divisions should be divided and the ganglion itself seized firmly. The first division is not so easily managed. Its upper surface is in relation to the cavernous sinus and the ocular nerves (Caution!), so it has to be cut or torn away close to the ganglion. The ganglion is now left hanging by its trunk, which has either to be divided or torn by drawing away the ganglion. The blood keeps pouring up from the depths of the funnel-shaped wound and must be carefully swabbed away during the whole of the operation if the surgeon is to see anything at all. After the ganglion has been extirpated a strip of gauze is introduced into the depth of the wound, the spatula is withdrawn and the brain allowed to sink back into place; the strip is left hanging from the posterior angle of the wound. Turn back the flap together with the zygoma and stitch up the wound in the soft tissues.

B. FACIAL OPERATIONS

1. *Operations on the Divisions of the Trigeminal.*

In the last chapter we described the extirpation of the Gasserian ganglion; we now proceed to the resection of the three divisions of the trigeminal nerve, operations which have to be undertaken fairly often on account of neuralgia. It is no longer the custom to perform simple division of these nerves: nerve regeneration takes place too rapidly for the benefit to be other than very temporary. The same remark applies to nerve stretching, an operation that should be reserved for such nerves as dare not be cut on account of the association of important motor tracts. We do not confine ourselves to resecting a stretch of nerve, but we follow Thiersch's directions and twist the nerve out, *i.e.* we seize the exposed nerve stem with the forceps, illustrated in Fig. 184, and slowly turn the instrument round on its long axis, thereby drawing out the nerve and winding it on to the arms of the instrument. It is possible in this way to extract a piece of nerve 4 in. to 6 in. (10–15 cm.) in length out of a comparatively small wound, and what is more, along with every one of its fine nerve twigs; a further advantage of the method lies in the fact that the central part of the nerve stem can be at least partially extirpated without any very thorough exposure being required. But though it is an easy matter to operate on the terminal branches, it is impossible to expose the stems at the base of the skull without the aid of a serious operation.

(*a*) *Exposure of the terminal branches of the three trigeminal divisions.*

The frontal nerve is a branch of the first division of the fifth, and enters the orbit through the sphenoidal fissure. It lies under the roof of the orbit, and divides into two branches, supraorbital and supratrochlear. The supraorbital nerve is the main branch and traverses the supraorbital notch at the superior orbital margin, the supratrochlear lying more internal. These nerves are exposed by a skin incision above the right eye, as represented in Fig. 185*a*. It is placed in the eyebrow itself, so as to prevent any evidence of scarring, and it divides the skin, the subcutaneous tissue and the orbicularis palpebrarum muscle. The supraorbital notch is easily palpable through the wound (occasionally the notch is converted into a foramen) : it does not lie in the middle of the supraorbital margin, but internal to it (Fig. 186), corresponding roughly to the inner edge of the cornea when the eye is directed straight forwards. Proceed carefully till the small supraorbital artery is found coming out with the nerve. The nerve itself at once breaks up into its terminal twigs. It can be seized at this point and drawn out (*v.* Figs. 186 and 187). The more central part of the nerve can easily be exposed through the same incision in its course alongside the supratrochlear nerve. In order to expose the two nerves in the orbit we must divide the palpebral ligament at the superior orbital margin, reflecting the upper eyelid along with it and drawing the contents

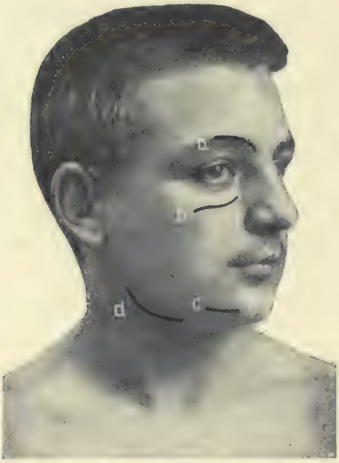

FIG. 185.—Incisions for the terminal branches of the three trigeminal divisions : (*a*) for the supraorbital nerve ; (*b*) for the infraorbital nerve ; (*c*) and (*d*) for the mental and inferior dental nerves.

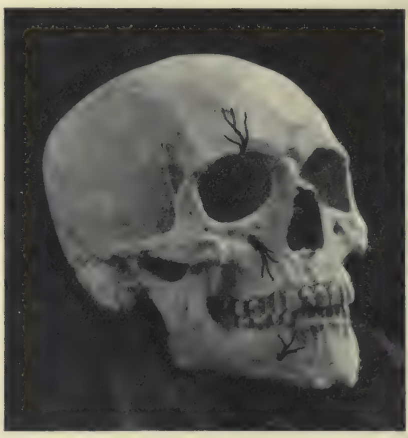

FIG. 186.—The terminals of the three trigeminal divisions, the supraorbital, infraorbital and mental nerves at their entrance to the face.

of the orbit carefully downwards with a blunt retractor: the nerves are then easily found.

The infraorbital nerve is the terminal branch of the second division. It arises from the Gasserian ganglion and leaves the base of the skull by traversing the foramen rotundum of the sphenoid bone: it gives off important branches as it crosses the sphenomaxillary fossa (of which the spheno-palatine is the largest) and enters the orbit through the spheno-maxillary fissure; it then lies immediately above the antrum of Highmore, running forward in the infraorbital canal. It appears in the face through the infraorbital foramen of the superior maxilla (*v.* Fig. 186), and sinks into the soft tissues of the cheek. Viewed from the front the infraorbital foramen will be seen to lie almost vertically below the supraorbital notch.

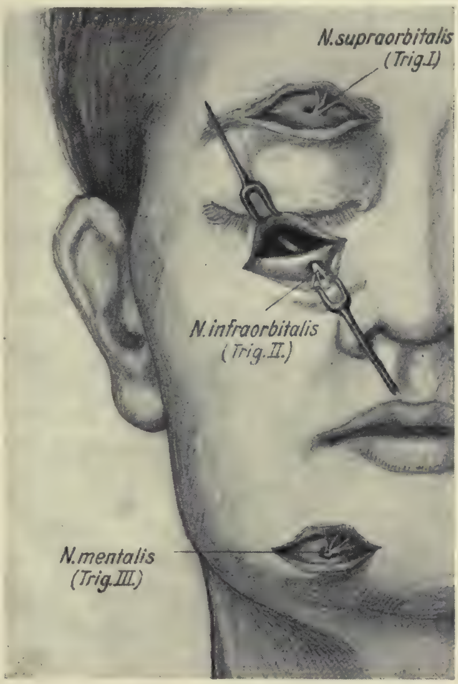

Fig. 187.—Exposure of the terminals of the three trigeminal divisions in the face.

Make a somewhat oblique incision in the fold of the skin beneath the eyelid (Fig. 185*b*), this being the best way of preserving the branches of the facial (Kocher). Proceed to strip the periosteum from the bone below the inferior orbital margin. Feel further downwards and try to palpate the infraorbital foramen; the nerve breaks up immediately, but it is easy to seize it at the exit and twist it out (*v.* Fig. 187). The side branches to the teeth, however, are given off in the interior of the maxilla, and as we desire to extirpate them too, it is a more rational procedure to expose the nerve in the orbit itself. Divide the palpebral ligament at the inferior orbital margin, pull up the lid and raise the periosteum in one piece from the floor of the orbit, so that we may not be troubled with fat projecting out from the orbit. The nerve is now seen shining white through the thin layer of bone that roofs in the infraorbital canal; on tracing it into the interior of the orbit it is found to run somewhat outwards as well as backwards. The thin bony lamella can often be opened with the point of the scissors, but the best way of removing it is to use a fine chisel and lift it out, as shown in Fig. 187. In chiselling this thin roof of bone we must be careful not to injure the thin roof of the antrum of Highmore which underlies the nerve. The infraorbital nerve is then seized on the floor of the orbit and twisted out, and the important superior alveolar twigs are almost certain to be eradicated at the same time. It should also be mentioned that scars on the face can be avoided if we expose the infraorbital nerve from the mouth as it lies in the canine fossa. Strongly evert the upper lip, divide the reflected fold of mucous membrane and work straight up on the periosteum of the upper jaw till the infraorbital foramen is reached.

The inferior dental nerve is surgically the most important terminal of the third division of the fifth. The third division leaves the interior of the skull by descending through the foramen ovale. It gives off a number of branches before dividing into its two main terminals, the lingual and inferior dental nerves. The latter is the principal object of peripheral operations. It descends between the external and internal pterygoid muscles, and sinks into the mandibular foramen on the inside of the ascending ramus of the lower jaw; the foramen is bordered by a sharp process of bone, the lingula. The nerve then traverses the mandibular canal and supplies twigs to the teeth of the lower jaw; it then appears at the mental foramen as the mental nerve, and soon divides into terminal twigs supplying the skin (*v.* Fig. 186).

A short incision is all that is needed to expose the mental nerve at the mental foramen. It lies in line with the second bicuspid tooth. A more conservative way is to pull the lower lip strongly downwards, incise the mucous membrane at the point of reflection and expose the mental foramen by stripping up the periosteum. If we twist out the nerve at this point it is unusual for more than a short piece of the central part of the nerve to be torn away, and the neuralgia in the lower teeth remains unaffected. There are a whole series of methods for exposing it more centrally. Chiselling of the mandible is the most important one. Begin by exposing the sharp edge of the angle of the jaw by means of a curved incision (*v.* Fig. 185*d*). Elevate all the tissues from the bone, especially the insertion of the masseter, until we are in a position to chisel the outer surface of the ramus or bore it through with a bur. This exposes the inferior dental nerve; it is to be freed if possible from the accompanying artery, and then raised from the mandibular canal on a small hook and slowly twisted out.

Other methods attempt to expose the nerve just before it disappears into the mandibular foramen at the lingula. Sonnenburg allows the head to droop and proceeds by way of a curved incision encircling the angle of the jaw. He slowly separates off all the tissues, especially the internal pterygoid muscle, as far as the lingula. Paravicini's method is to operate through the open mouth ; he divides the mucous membrane at the anterior border of the ascending ramus, and works on below the periosteum on the inside of the bone till the lingula and the mandibular foramen are reached.

(*b*) *Exposure of the second and third divisions of the trigeminal at the base of the skull.*

We have here to deal with such a number of methods that it is quite impossible to refer to every one. A common feature of them all is that access to the deep spheno-maxillary fossa and foramen ovale is obtained by making a temporary opening in the bony cranium and dividing the second division at the foramen rotundum, the third division at the foramen ovale.

Kocher exposes the second division of the trigeminal by a skin incision that conserves the branches of the facial ; it starts at the infraorbital foramen, and is carried horizontally outwards along the malar bone and zygoma. The malar bone is then exposed, its muscles detached, and its bony connections divided in order to let it be temporarily turned outwards The division of the zygoma is simple ; but the malar is to be divided at its juncture with the superior maxilla in such a way that the chisel is made to traverse the infraorbital foramen and open up the whole of the infraorbital canal as far as the spheno-maxillary fissure. The frontal process of the malar is also divided in such a way that the chisel cut ends in the spheno-maxillary fissure. Free the osteoplastic flap on all sides and reflect it outwards, and we are now able to detach the lateral half of the orbital floor and part of the lateral wall of the antrum (which is opened in the process) and follow the infraorbital nerve upwards. The spheno-palatine nerve can be seen leaving the common nerve stem behind the antrum of Highmore, and we are able to divide the stem itself close up to the foramen ovale, *i.e.* central to where the spheno-palatine comes off. The peripheral end is then extracted.

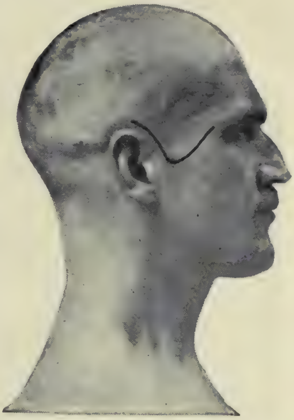

FIG. 188.—Kocher's incision for exposure of the third trigeminal division at the base of the skull.

In exposing the third division at the base of the skull Kocher employs the angular incision shown in Fig. 188. It starts at the outer end of the eyebrow, slants downwards to the temporal root of the zygoma and then turns up nearly at right angles to end just above the ear. The cut divides the superficial tissues and the temporal fascia, and the superficial temporal artery is ligatured in two places and divided. Bare the zygoma in front and behind, divide it with saw or chisel, and turn it downwards. Then divide the temporal muscle at the coronoid process or bite away the process with bone forceps, and retract it well forwards. Proceed on slowly through the vascular soft tissues till the pterygoid process of the sphenoid is reached; the foramen ovale, through which the third division passes, will be found behind the root of the external pterygoid process. (For a proper understanding of these anatomical relations the beginner as well as the expert should make use of a skull.)

(*c*) *Krönlein's operation for the simultaneous exposure of the second and third divisions at the base of the skull.*

It runs as follows: Fashion a temporal flap with its base upwards and its terminals at the upper border of the zygoma, and throw it upwards. Cut across the temporal fascia at the upper border of the zygoma, and chisel through the zygoma in front and behind in the lines given in Fig. 189, thus enabling it to be turned down along with the masseter muscle. The temporal muscle now comes into view; follow it downwards to its tendon and expose a considerable portion of the coronoid process; divide the latter as in Fig. 189, and throw it upwards with the temporal muscle. The infratemporal crest, external pterygoid muscle and internal maxillary artery are now exposed. Ligature the last of these, free the external pterygoid from the infratemporal crest, and, going still deeper, expose the foramen ovale behind the root of the pterygoid process. The third division should be resected at this point. The middle meningeal artery runs just behind it, entering the skull through the foramen spinosum. Ligature of the internal maxillary artery is of equal service in the case of the second division. Dissect bluntly down into the spheno-maxillary fossa, keeping to the posterior surface of the superior maxilla, and retracting the soft tissues backwards. Expose the spheno-maxillary fissure and there the second division of the trigeminal will be found running forwards at a considerable depth. It is to be followed backwards and resected at the foramen rotundum.

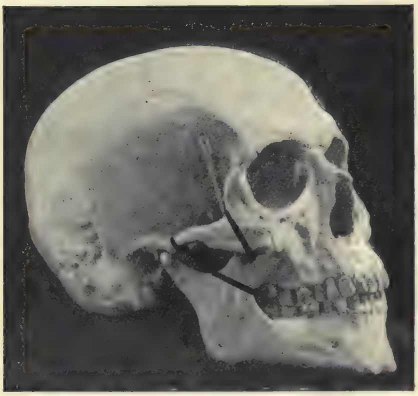

FIG. 189.—Lines for dividing the bones in exposure of the second and third divisions of the trigeminal at the base of the skull.

All osteoplastic methods conclude with a careful replacement of the temporarily resected bone, which must then be sutured in place. Drainage of the deep funnel-shaped wound is an essential feature in the after treatment.

2. *Bellocq's Method of Nasal Tamponade.*

In a number of operations on the face and nose and in the treatment of severe epistaxis it is of importance for us to be able to apply a firm tamponade to the nasopharynx and prevent the blood from pouring into the deeper parts of the throat. Bellocq's method is far and away the best ; his sound is illustrated in Fig. 190. Retract the stilette into the sound, and introduce the instrument along the inferior meatus as far as the nasopharynx. Then take out the handle and push out the spiral stillette till its round end appears in the mouth. Seize it and thread a stout silk suture through the eye at its end ; this suture is firmly attached to a firmly rolled tampon. This stage of the operation is represented in Fig. 191. The sound is then withdrawn from the anterior nares, the suture is pulled after it and the tampon becomes impacted in the posterior nares. Another silk suture is attached to the tampon, with a view to its subsequent removal ; this hangs out at the mouth and should be fastened to the cheek with a strip of plaster.[1]

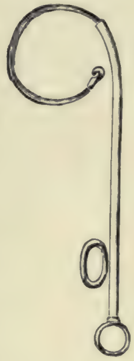

FIG. 190.—Bellocq's sound.

3. *Chiselling of the Frontal Sinus.*

The frontal sinus is opened on account of suppuration in order to secure the permanent drainage of its contents. We must recollect that the two sinuses are separated by a septum which does not always lie in the middle line, and their extent is very variable as regards height, breadth and depth. The sinus can invariably be reached by chiselling its anterior wall at the inner end of the eyebrow immediately above the upper bony margin of the orbit. The incision is made in the inner half of the eyebrow itself ; it divides everything down to the bone, including the branches of the first trigeminal division that runs upwards on to the forehead. Shell off the periosteum upwards and downwards, and carefully chisel up the bone with a narrow gouge immediately above the inner half of the orbital margin, till the bluish mucous membrane comes into view. The membrane is then opened and the extent of the frontal sinus ascertained with the help of a flexible probe. In cases where removal of the pus is indicated the operation will not be permanently successful unless we clear out the entire mucous membrane and establish a wide channel for the secretions to pass into the nose. To effect this we gradually enlarge the opening in the bone with fine forceps (Luer's) until the whole cavity is exposed. It is only then that its real extent and sinuous shape can be appreciated in any single instance; uneven bosses of bone project into the lumen on the deep aspect, there being caused by the irregularly shaped ethmoidal cells immediately behind the sinus. After carefully scraping out the mucous membrane, try to pass a fine sound into the nasal cavity (middle meatus). Do not rest content with this, however, but take a small narrow sharp spoon and entering from the nasal cavity bore a wide path into the frontal sinus. Pass a drain through the channel into the frontal sinus till it appears at the nose, and suture the skin over the wound of operation with a close stitch.

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[1] A gum-elastic catheter is a good substitute for Bellocq's sound.—TR.

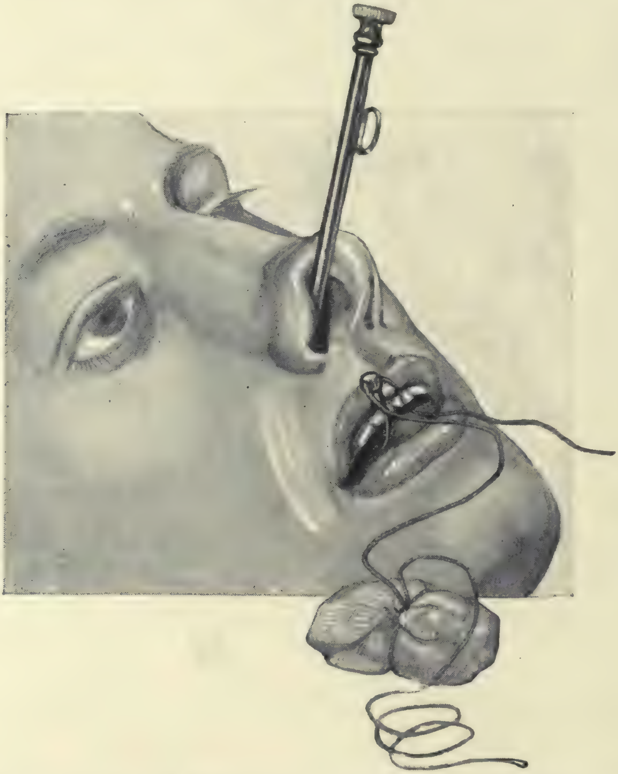

FIG. 191.—Tamponade of the posterior nares by means of Bellocq's sound.

This method affords a permanent cure, but the scar is apt to become in-drawn at the point of chiselling. Osteoplastic openings have therefore been undertaken to turn down the anterior wall of the sinus in the form of a flap of skin, periosteum and bone.

Frequently, however, the suppurative process does not confine itself to the frontal sinus but invades the neighbouring ethmoidal cells or even the sphenoidal sinus itself, and necessitating a much more radical exposure. Killian's radical operation is the most important one in chronic suppurations of these cavities, and a unilateral exposure is represented in Fig. 192. Commence once more with an eyebrow incision, and on reaching the inner end of the eyebrow carry the cut directly downwards at the inner canthus a few centimetres on to the side of the nose. Before commencing to separate the periosteum as in simple anterior chiselling, make a thorough exposure of the periosteum covering the superior orbital margin and with two parallel cuts into the periosteum mark out a bridge of periosteum and bone about $\frac{1}{3}$ in. broad ($\frac{3}{4}$ cm.) along the upper edge of the orbit; this is to be retained. Shell back the periosteum above and below this bridge; above, as far as we just described for anterior chiselling, and below, advancing well into the orbit, pushing down the trochlea and exposing the frontal process of the superior maxilla. The chiselling is done by means of fine bent forceps (Luer's), and it must be continued till the sinus has been thoroughly opened up, with the exception of the osseous bridge. This makes it easy to penetrate the thin-walled ethmoidal cells, to expose them

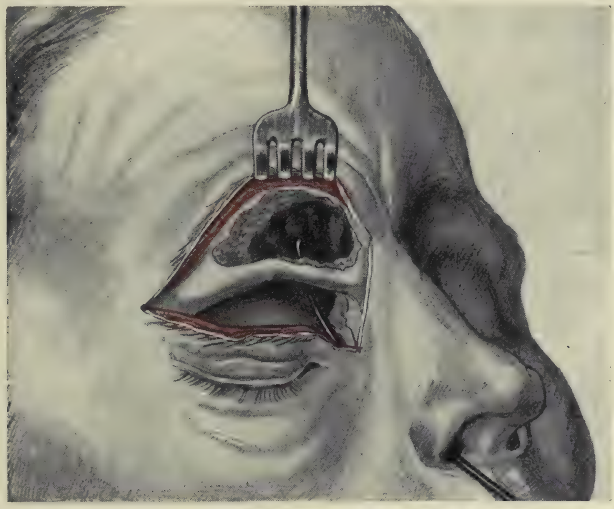

FIG. 192.—Killian's radical operation for frontal sinus suppuration. The operation has only been carried out on the one side.

thoroughly and after removing the anterior part of the middle turbinate to establish a really effectual communication with the nose. A splendid view of the parts is now obtained and we are in a position to remove the entire mucous membrane. A good result may then be expected. This wound may also be stitched up, but not till after thorough cleansing and drainage into the nose (Fig. 192).

4. *Chiselling of the Antrum of Highmore.*

The antrum is a cavity in the superior maxilla about the size of a chestnut. It is opened to permit the free egress of purulent collections (empyema of the antrum). The aim of the operation is to open at a point favourable to the exit of the secretion, drain the antrum and flush it out daily and keep it open until healing has occurred. Three possible methods are available:—

(*a*) Opening in the canine fossa is the best and most thorough method; it consists in chiselling the anterior wall of the maxilla. Pull the upper lip well upwards on the affected side, divide the mucous membrane at the line of reflection and elevate all the soft tissues with the help of a large retractor from the anterior surface of the upper jaw. Select a point above the fangs of the teeth opposite the second bicuspid and chisel an opening in the anterior wall of the antrum. Through such an opening the antrum can be partially inspected and thoroughly palpated, and the pus drains readily away.

(*b*) Drainage through one of the alveoli is much less effectual. Open the mouth and extract the second bucuspid tooth. Then take a small sharp spoon and bore vertically upwards in the direction of the root canal till you penetrate into the antrum. Drain.

(*c*) The unpleasantness of having a constant flow of pus into the mouth, and a continual blocking of the drainage passage with food from the mouth is obviated by puncturing with a trocar. This is of course purely palliative, for the instrument does not strike the antrum at its deepest point. Introduce a bent trocar into the inferior meatus, point it outwards and thrust it into the cavity.

If the cases are difficult and obstinate, and a thorough removal of the disease is demanded, we combine methods 1 and 3. Begin by chiselling a large opening in the canine fossa, remove the pathological contents and the diseased mucous membrane, and then establish a wide communication from the inside of the nose by chiselling away the thin median wall of the superior maxilla. As soon as you are sure of a good outflow into the nose, you can restitch the divided mucous membrane and allow it to heal up. This last combined method must be carefully practised on the dead subject.

5. *Enucleation of the Eyeball.*

From the whole range of eye operations we shall practise only one, the removal of the eyeball. Every practitioner may at some time or other have occasion to perform it. When the eyeball is removed by itself, we speak of Enucleation of the bulb; when all the soft tissues of the orbit, *i.e.* the ocular muscles, fat and periosteum have to be taken away, we speak of Excavation of the orbit, a more drastic and distinctly unusual operation.

In Enucleation of the Bulb the first step is to force open the eyelids with special forceps or, better, by the use of two small retractors. Then lift a fold of the conjunctiva bulbi from off the white sclerotic and incise it with a snip of the scissors. Starting at this opening make a circular incision in the conjunctiva some few millimetres from the corneo-scleral junction all round and push it backwards on all sides. Then separate the four recti muscles from their insertion into the sclera at a point about ⅓ in. (¾ cm.) behind the edge of the cornea; raise the muscles one by one with a strabismus hook (Fig. 193) and divide them close to the bulb with fine scissors (*v.* Fig. 194). It is now easy to push the eyeball out, introduce Cooper's scissors from the nasal side and divide the optic nerve and the opthalmic artery. The eyeball now prolapses out of its fatty bed and the two oblique muscles are divided. This completes the enucleation. The hæmorrhage from the ophthalmic artery is usually severe, so the orbit should be packed tightly with gauze for some minutes, after which the vessel should be seized and ligatured.

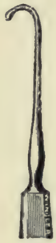

FIG. 193.—Blunt strabismus hook.

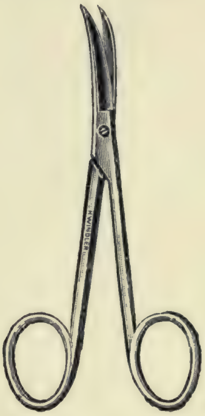

FIG. 194.—Fine pointed scissors.

In Excavation of the Orbit the first step is to widen the palpebral fissure; this is facilitated by an additional incision outwards at the external canthus of the eye. Incise the conjunctiva bulbi all round near the superior fornix and divide the soft tissues and periosteum all round the bony orbit. Then take a blunt elevator and separate the periosteum from the bone on all sides till it is possible to divide the optic nerve and the ophthalmic artery with scissors: the orbital contents are drawn out at the same time with toothed forceps. The resulting hæmorrhage is as severe as in simple enucleation but may be controlled in the same way.

In removing retrobulbar tumours of the orbit it is not always necessary to sacrifice the eyeball. Krönlein has given us a modified osteoplastic method; in his operation he turns back the external bony margin of the orbit and lets it heal up again in place. This method exposes the posterior half of the orbit together with the stem of the optic nerve.

6. *Excision of the Superior Maxilla.*

Excision of the superior maxilla is performed for the extirpation of malignant growths. The periosteum is always removed in those cases; subperiosteal resection is therefore contraindicated in practice on the dead subject. We shall begin by describing complete unilateral excision of the upper jaw.

The beginner should take a skull in his hand and consider the way in which this large bone, which forms such a considerable part of the face, is dovetailed into the other bones. The alveolar process projects down from its anterior surface and carries the teeth (*v.* Fig. 197). Internally it forms the edge of the pyriform aperture, which opens into the nasal cavity. Its frontal process articulates with the nasal and frontal bones. It forms the lower margin of the orbit and sends the stout zygomatic process to join the malar bone. Its inner wall looks into the nasal cavity, its upper wall forms the inferior surface of the orbit, its lower wall forms the hard palate and is closely united with the palatal process of the opposite superior maxilla. Posteriorly the upper jaw is connected with the pterygoid processes of the sphenoid. The interior of the bone is hollow, containing the large antrum of Highmore.

A knowledge of these bony connections is absolutely essential for the typical excision of the upper jaw, since it is by no means easy to separate it from the other bones of the face.

There are quite a variety of skin incisions. Which should we choose? Fig. 195 shows Dieffenbach's original skin incision (*a*) from the inner canthus to the bridge of the nose and thence vertically downwards, splitting the nose and the upper lip. In Langenbeck's accessory incision (*b*) a flap is formed with its base at the lower eyelid. Velpeau (*c*) carries a curved incision through the cheek from the angle of the mouth. It is a waste of time to get up all these methods and we recommend the reader to confine his attention to the incision named after Dieffenbach-Weber. It is represented in Fig. 196. Begin by dividing the upper lip in the middle line; the incision then encircles the nostril and the ala of the nose (where the resulting scar is scarcely visible), it then passes obliquely upwards almost as far as the inner canthus and then curves under the lower eyelid in the fold of the skin. Kocher does not continue it to the outer canthus but slants it downwards and lets it end at the malar bone. This last cut is planned to avoid the fibres of the facial nerve that supply the muscles around the eye. The skin incision is carried down to bone in its whole extent and it enables one to raise a large flap of the soft tissues from the anterior surface of the jaw and throw it outwards, as represented in Fig. 199. The advantage of such a flap is obvious ; the resulting scars are scarcely visible ; but quite apart from this the pedicle of the flap lies to the outside, and it follows that the skin incision steers clear of (1) the main arteries, (2) the branches of the facial to the muscles of emotion, and (3) Stenson's duct as it comes from the parotid.

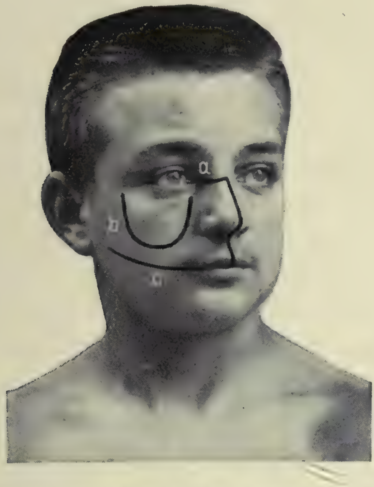

FIG. 195.—Various incisions for the excision of the upper jaw: (*a*) Dieffenbach's ; (*b*) Langenbeck's ; (*c*) Velpeau's.

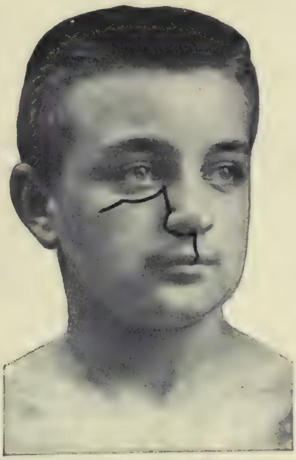

FIG. 196.—Incision for the resection of the upper jaw, after Dieffenbach-Weber (with Kocher's modification).

Although the soft tissues are separated away the periosteum is left. Strip every other bit of tissue off the anterior surface of the bone. Free the anterior half of the masseter muscle from the zygoma. Incise the periosteum at the lower orbital margin and raise the soft tissues from the floor of the orbit ; in doing so leave the loosened layer of the orbital periosteum quite intact, so as to prevent the fat of the orbit from prolapsing into the cavity of the wound. The cartilaginous part of the nose has also to be detached on the side of the disease from the edge of the pyriform aperture and an entrance effected into the nasal cavity (cp. Fig. 199).

The bony connections of the superior maxilla must now be divided at four points : the four lines are indicated in Fig. 197. Divide the malar bone first of all with a wire saw ; in doing this employ a Ferguson's needle (Fig. 198) or pass a flexible ear probe through the spheno-maxillary fissure and bring it out below the zygoma ; carry the wire saw round the bone and divide the malar as far out as is necessary. Secondly, the frontal process of the superior maxilla must be divided ; introduce the wire saw at the pyriform aperture, perforate through the lacrimal bone into the nose and encircle and divide the process. Thirdly, there follows the median division of the hard palate and the separation of the one palatal process from the other. But first of all we must know how to deal with the soft palate ; if it is implicated in the disease, the knife should be made to divide the muco-periosteum of the hard palate and to penetrate right through the soft palate ; the first incisor is then extracted on the affected side, the wire saw carried through the nose and throat and the hard palate sawn through. In many cases, however, it is possible to retain the soft tissues of the palate, which is a considerable advantage ; in this case slant the cut outwards after dividing the soft tissues of the hard palate, and end it just behind the last molar tooth. It is even possible in some instances to preserve the muco-periosteum covering the hard palate by making an incision near the inner side of the teeth and raising a flap of the soft tissues as far as the middle line. In every case the bone should be divided in the mid line. The chisel can be used instead of the saw for dividing the bone ; the method is quicker and would seem an advantage in view of the amount of blood that is lost in operations in the living subject. The fourth and last division of the bone is done to separate the back of the superior maxilla from the pterygoid process of the sphenoid ; open the mouth to the full, apply a chisel at the back of the last molar tooth and with a nearly vertical cut upwards sever the bony connection. Fig. 197 shows the four lines of division on the skull ; Fig. 199 represents the reflected flap of the soft tissues and the division of the frontal process with the wire saw.

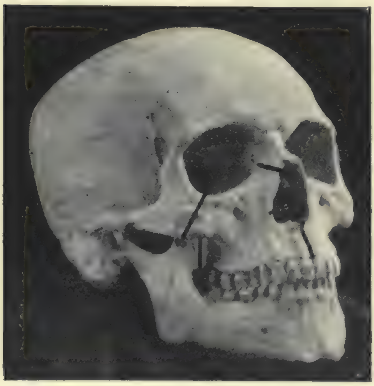

FIG. 197.—The four lines of bone division in the excision of the upper jaw.

It is now possible to evulse the jaw, for the remaining deep connections of the bone are of little account. It may be forced out with a strong elevator, or seized with lion forceps. Violent bleeding occurs on tearing it out, because the branches of the internal maxillary artery are torn across in the process; control it for the time being with a firm tampon and then introduce some ligatures; the most effectual way is to seize the internal maxillary artery itself.

Before we speak of closing the wound, it should be mentioned that excessive loss of blood can be prevented by preliminary ligature of the external carotid artery; it has also been proposed to clamp the common carotid. Blood can be prevented from entering the lungs by tracheotomy and the introduction of a tampon cannula (*v.* Figs. 228 and 229); but the majority of surgeons have given up this method as being too drastic, and peroral intubation (Kuhn) has taken its place. Bellocq's tamponade of the naso-pharynx is a great help in the first stage of the operation; the method has already been described and illustrated on page 147; it is especially useful during the typical divisions of the bone. The tampon can be removed as soon as the maxilla has been extirpated.

At the end of this severe operation it is possible to inspect the wound opening and the adjoining cavities of the nose, throat and mouth, which are now converted into one large cavern. Note particularly that the complete removal of the superior maxilla deprives the eye of its chief means of support—the inferior orbital plate. It was proposed in view of this to retain the floor of the orbit whenever the extent of the disease would permit of it, and to perform an atypical and incomplete resection. The question of this limited operation arises in cases where the hard palate is the chief seat of the disease. On the other hand we are sometimes able to retain more of the hard palate.

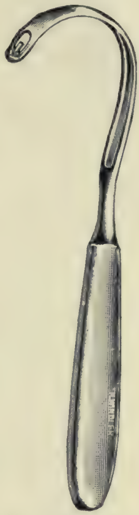

Fig. 198.—Ferguson's needle.

The chief point in the suture of the wound is to secure a soft tissue partition between nose and mouth. This is got at once when the soft palate and the muco-periosteum of the hard palate can be retained; it is quite easy to suture them to the reflected edge of the buccal mucous membrane (Fig. 199). Before doing so, however, one should insert enough gauze to tampon up the resection cavity, the end of the tampon being drawn through the nose on the affected side. The wound in the face is then stitched up. But when the soft palate has been removed do not attempt to form an oro-nasal diaphragm, but pack the cavity with a firm gauze tampon (to be extracted later through the mouth). Make a careful closure of the wound of the face and leave the cavity to granulate up. An artificial palate is introduced later, with a large prolongation into the resection cavity for the support of the eyeball.

In addition to the extirpation just described it is possible to perform a temporary resection of the upper jaw, *i.e.* to carry out an osteoplastic displacement in order to reach the naso-pharynx and the base of the skull. Many methods are based on Langenbeck's original incision, but it is impossible to make individual mention of them here, although they are easy to perform on the subject. They are adapted to the needs of the individual case and vary not only in the skin incisions (for the base of the flap may be internal or external or downwards) but also in the saw lines through the bones, the maxillary flap consisting sometimes of the whole bone and sometimes only of a part. In the dead subject it is best to plan the incision as for total resection, above described. For temporary resection

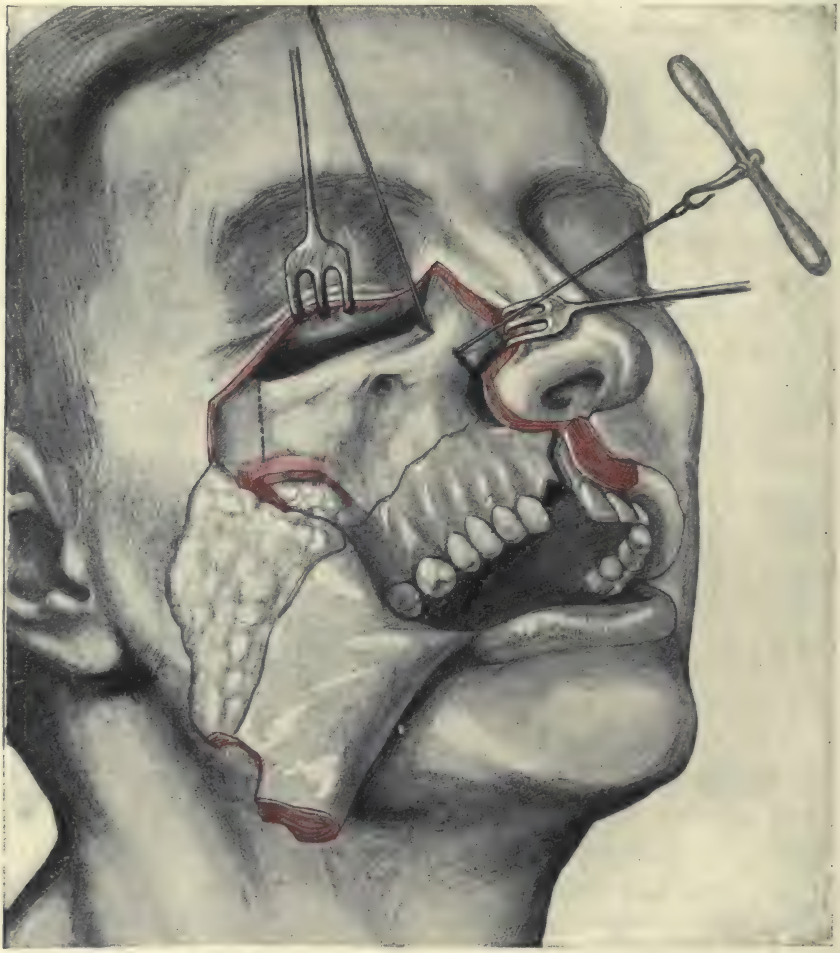

FIG. 199.—Excision of the upper jaw after Dieffenbach-Weber-Kocher.

the skin is incised as in Fig. 196. The soft tissue flap is not separated, but the nasal cartilage is severed and the bony connections are divided. The chisel is the best instrument to use. The hard and soft palates are split up in the middle line. The flap of skin periosteum and bone is then turned out like the wing of a door and is replaced later. The divided tissues of the face and palate must be carefully stitched. The bone need not be sutured.

7. *Excision of the Lower Jaw.*

Excision of the lower jaw is a resection in continuity, *i.e.* you make a transverse section of the bone and remove a piece. The after treatment is not at all easy and can scarcely be carried out without the aid of artificial apparatus. The extent of the excision will depend therefore, not only on the site of the disease, but on whether such a prosthesis can be easily applied to the stump. Experience teaches that there is no point in retaining the ascending ramus alone ; if the whole horizontal ramus must be removed it is best to excise one half of the lower jaw in its entirety. We regard this as the typical operation ; it is easy to practise it on the subject.

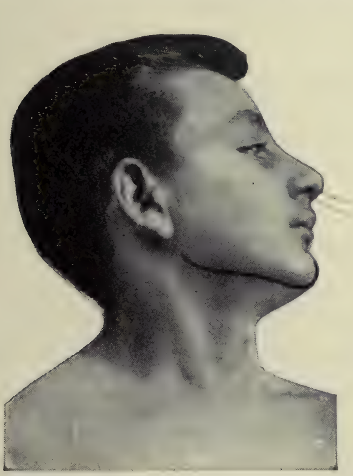

FIG. 200.—Incision for the resection of the lower jaw.

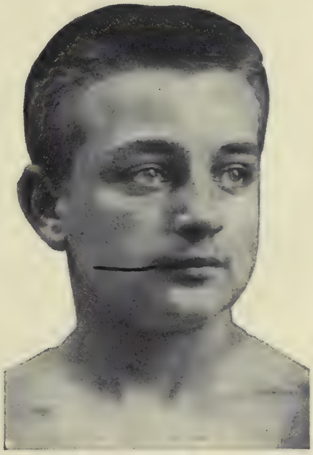

FIG. 201.—Horizontal incision for exposure of the tongue.

Bend back the head and turn it to the sound side. The skin incision is made as in Fig. 200. It divides the under lip in the mid line, is continued downwards to the under surface of the chin and then passes backwards parallel to the horizontal ramus ; it should lie not on the inside of the jaw but below it, to prevent the scar being seen ; it is carried about a thumb's-breadth upwards behind the angle of the jaw. Cut down to the bone in the whole extent of this horizontal incision, dividing the platysma, the deep fascia of the neck and the facial artery. The nature of the disease will then determine whether the excision is to be subperiosteal or not, *i.e.* whether the flap should be raised from the periosteum or the periosteum from the bone. Sharply retract up the edges of the wound and clear the tissues from both surfaces of the bone, using excision knife and elevator in turn: the latter is chiefly used for freeing the insertion of the masseter and for clearing the outer side of the bone. The peripheral branch of the third division of the fifth nerve appears at the mental foramen (cp. Figs. 186 and 187) and should be divided. The soft parts are also elevated and retracted at the anterior vertical cut, and the central incisor on the affected side should be extracted. Introduce a Ferguson's needle (Fig. 198) at the line of excision, passing it from the floor of the mouth and forcing it through the soft tissues at the inner side of the jaw; pull a wire saw after it and saw through the bone in the interval between two teeth. Next insert a single-toothed retractor (Fig. 29) into the divided bone on the side of the disease, and draw it downwards and outwards. This puts the retaining soft tissues on the stretch; divide the mucous membrane both on the inside and outside of the bone, free the numerous muscular insertions and the lower jaw will follow the pull of the retractor more and more. Divide the inferior dental nerve at its entrance into the mandibular canal and free the internal pterygoid muscle from its insertion. The fixation of the jaw now chiefly depends on the insertion of the temporal muscle into the coronoid process; retract up the soft tissues thoroughly and expose this part of the bone, divide the muscle at its tendinous insertion or nip off the tip of the coronoid process. The lower jaw now hangs merely from the capsule of the temporo-mandibular joint; this should be exposed and carefully divided. This part of the operation is done at a good depth, and there is a danger of damaging the internal maxillary artery as it runs on the inside of the joint; it is therefore often advisable to have recourse to the somewhat crude but quite effectual manœuvre of tearing out the articular head by twisting it on its long axis. The after treatment of the wound consists in a careful catgut suture of the mucous membrane. Such details belong really to more elaborate text-books.

8. *Extirpation of the Tongue.*[1]

Operations on the tongue itself are easy. It is scarcely worth practising the simple suture of a wound or the wedge excision of a part with its after suture.[1] The more complex operations, however, are instructive and important; they enable us to inspect the oral cavity and give us access to the posterior and deeply-fixed parts of the tongue. The typical ligature of the lingual artery is an essential preliminary to all radical excisions of the tongue (*v.* Fig. 22).

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[1] The apical lymphatics of the tongue and those from the anterior part of the floor of the mouth drain to the submental nodes and inferior deep cervical nodes. The other

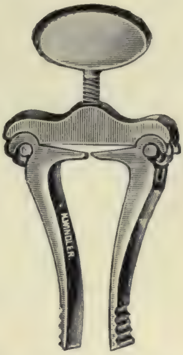

FIG. 202.—Oral speculum (Heister's).

(*a*) The simplest method is to open the mouth, introduce a strong silk suture through the middle of the tongue, draw it well forwards, do a V-shaped excision of the diseased area and suture up the wound.

(*b*) If this is insufficient, and especially if the seat of the disease is at the side of the tongue, add a transverse cut through the cheek, slitting it from the angle of the mouth almost as far as the anterior border of the masseter. We are not anxious to incise any further back, as there is a risk of injuring Stenson's duct as it comes from the parotid gland; the duct, it will be remembered, runs in a line from the root of the lobule of the ear to midway between the ala of the nose and the red of the upper lip and disappears by dipping down towards the mouth at the anterior border of the masseter. If the edges of the wound are retracted and an oral speculum introduced between the teeth on the sound side, this accessory cut will afford the operator a splendid view of the whole mouth. The wound in the cheek is sutured up later, catgut being used for the mucous membrane and silk for the other tissues.

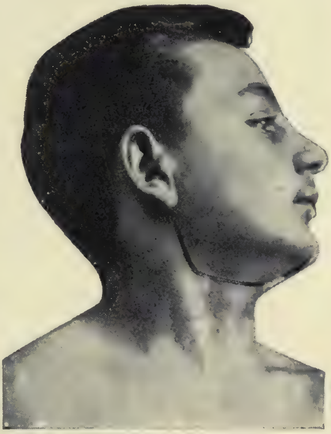

FIG. 203.—Kocher's submental incision for exposing the floor of the mouth and the tongue.

(*c*) Access to the tongue can also be obtained by means of the submental incision (perfected by Kocher). This method is particularly useful when not merely the tongue, but also the floor of the mouth, has been infiltrated with disease. It is performed as follows: The skin incision

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lymphatics drain to the superior deep cervical nodes and especially to one situated a little above the carotid bifurcation: this gland has therefore been termed the "principal lingual node."

An excision of the tongue is nowadays regarded as incomplete when the areas of lymphatic drainage are not extirpated along with the primary focus of disease.—TR.

[1] Note, however, that omission to suture a torn tongue may result in loss of life.—TR.

begins below the mastoid process and follows the anterior edge of the sterno-cleido-mastoid muscle as far as the level of the hyoid bone. From here it curves forwards and ends below the chin at the mid line of the neck; it is represented in Fig. 203. Raise the flap of skin as far as the inferior border of the jaw and draw it upwards. Divide the deep cervical fascia, raise the submaxillary gland from out its capsule and extirpate it, severing Wharton's duct in the process. Expose the trunk of the facial artery (it lies postero-lateral to the submaxillary) and divide it between two ligatures. The deep hypoglossal triangle is now exposed; we already know it from the description of the lingual artery; the lingual should now be ligatured. Attention should next be paid to the muscles inserted into the outer and inner surfaces of the horizontal ramus. The mylo-hyoid muscle comes first and is divided parallel to the lower jaw and close to its insertion into the mylo-hyoid ridge; this ridge is easily palpable on the inner surface of the jaw; it is now possible to proceed behind the muscle and enter the mouth. The mucous membrane must now be freed from the jaw in front and behind in the line of the incision; free separation is necessary, and eventually we overstep the mid line, seize the tip of the tongue, draw it well out of the wound and extirpate the diseased area together with a part of the floor of the mouth.

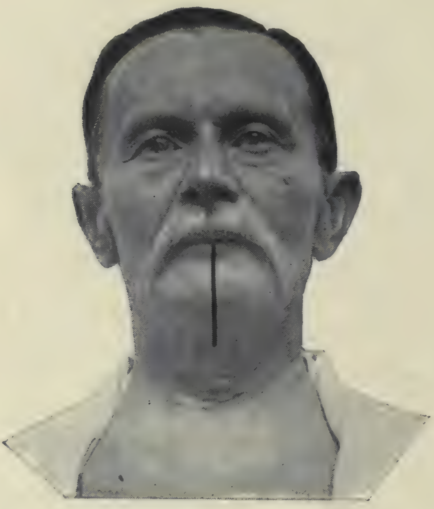


Fig. 204.—Incision for the extirpation of the tongue, after lateral division of the lower jaw.

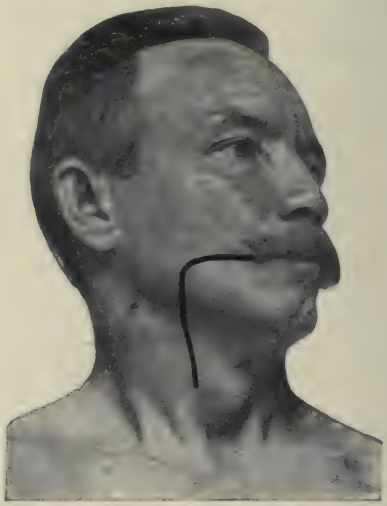


Fig. 205.—Incision for extirpation of the tongue with lateral division of the lower jaw (v. Langenbeck).

(*d*) Temporary division of the lower jaw is far and away the most interesting accessory operation for the removal of extensive carcinomas of the tongue. We practise it carefully on the subject. The division of the lower jaw is effected either by a longitudinal median cut, or by making a curved incision from the angle of the mouth and sawing the bone opposite the first molar tooth. The first method is the more conservative, as it preserves the branches of the facial to the mouth; the second is the more practical in cases where the tumour lies lateral and deep, and is the one we shall describe.

The assistant compresses the angle of the lower lip with finger and thumb, while the operator does the same for the upper lip; this puts the soft tissues of the cheek well upon the stretch. Incise the cheek from the angle of the mouth as far back as the anterior border of the masseter muscle; then curve the incision directly downwards to the anterior edge of the sternomastoid, meeting it opposite the upper border of the thyroid cartilage. Divide the platysma and the deep cervical fascia in the whole length of the incision. This exposes the submaxillary gland. Free it from its bed of loose areolar tissue and lift it outwards and upwards. Expose and ligature the facial artery and excise the whole submaxillary gland; the facial must usually be divided a second time at the upper border of the gland. In the living subject the associated lymph glands are removed along with the submaxillary. Then perform a typical ligature of the lingual artery in the deep hypoglossal triangle. Next extract the first molar and guided by the finger pass a Ferguson's needle (Fig. 198) round the horizontal ramus close to the bone, apply the chain saw and divide the bone opposite the cavity of the extracted tooth. The bone is not divided straight through but sawn from above and behind obliquely downwards and forwards, as shown in Fig. 206. This precaution is necessary to prevent the dragging up of the posterior fragment and the dislocation down of the anterior fragment, as such a condition would gravely interfere with osseous union. Holes should be bored in the bone before it is sawn (Fig. 206), so that the divided ramus can be sutured up later with silver wire; it is easier to do the boring previous to dividing the bone. After the bone has been sawn through insert a hook into the mandibular canal on each side and pull the

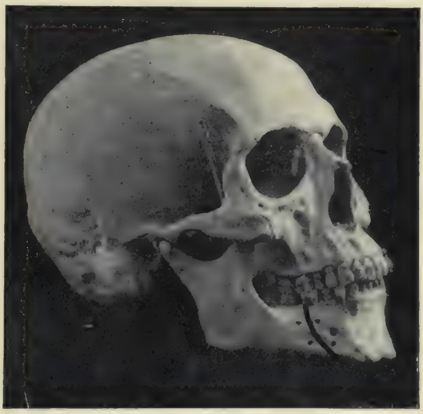


FIG. 206.—Bore-holes and oblique saw-cut in the temporary division of the lower jaw for exposure of the tongue.

two fragments strongly outwards. The tense mucous membrane must be separated from the inside of the lower jaw and the mylo-hyoid muscle from

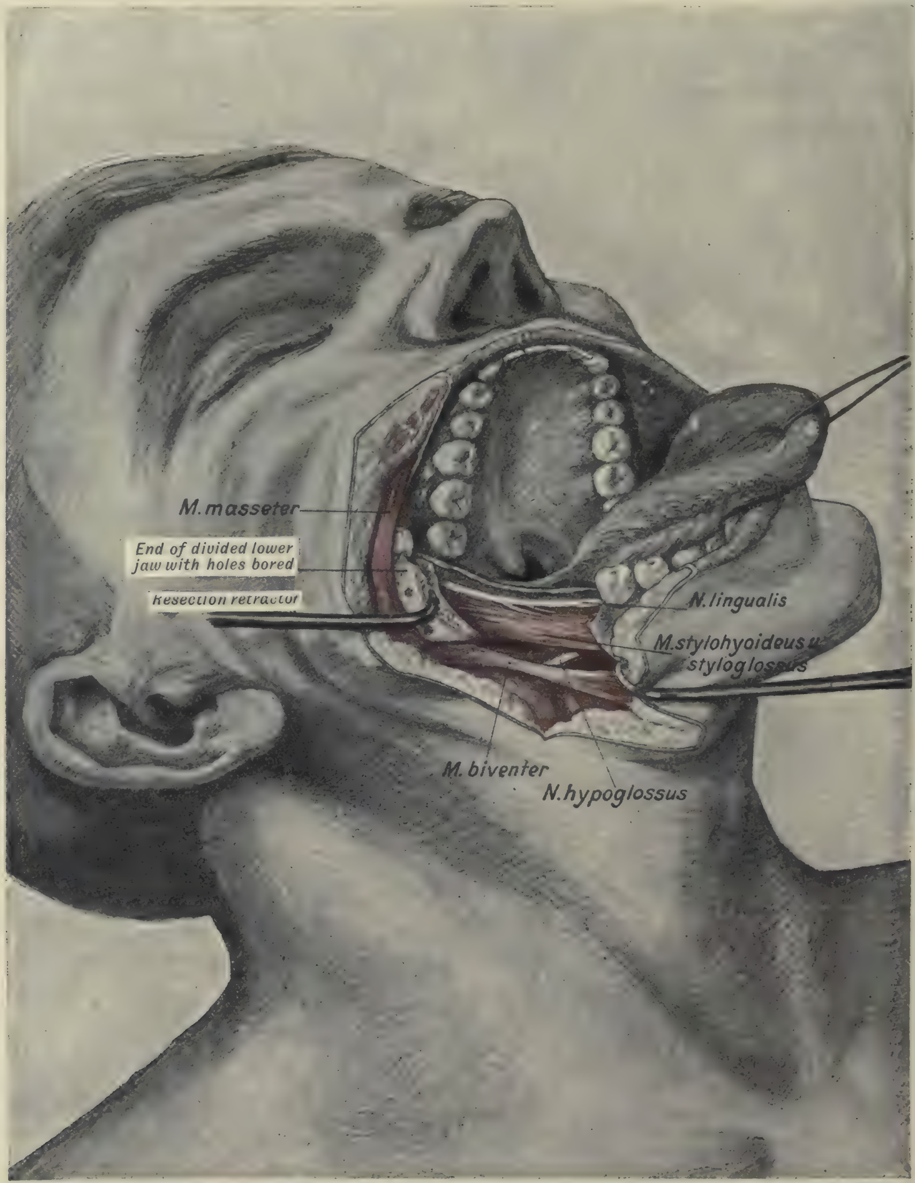

M. masseter
End of divided lower jaw with holes bored
Resection retractor
N. lingualis
M. stylohyoideus u. styloglossus
M. biventer
N. hypoglossus

FIG. 207.—Exposure of the tongue after temporary lateral division of the lower jaw (v. Langenbeck).

the mylo-hyoid ridge. We are then presented with such a picture as in Fig. 207. We look into the open mouth and can see the soft palate, the pharynx, the tonsils, and, it may be, the epiglottis, and the tongue right back to its base. The wound is bounded above by the cut edge of the mucous membrane. Close below this the lingual nerve is seen passing down in relation to the internal pterygoid muscle and running on to the tongue. The hypoglossal nerve is thicker and is found running at a deeper level in association with the lingual vein ; it lies on the hyo-glossus muscle and crosses the line of its fibres. The stylo-hyoid and stylo-glossus muscles can be seen between these two nerves, running down from the styloid process ; the digastric muscle is seen below the hypoglossal, with its tendinous attachment to the hyoid bone. The hyoid bone is easily palpable in the wound. Put the soft tissues well upon the stretch by means of retraction hooks, raise them all with the forceps and divide them in turn with snips of the scissors. We can inspect the field of operation much more fully after dividing the lingual and hypoglossal nerves and the digastric muscle.

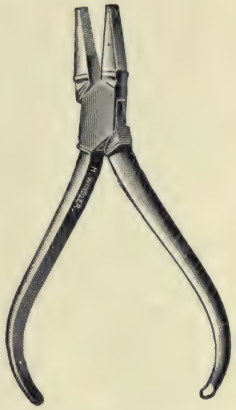


FIG. 208.—Wire pincers.

In the living subject there is considerable hæmorrhage right through the operation and it needs the strict attention of the surgeon to control it. An assistant should also watch that no blood runs down into the throat. Bearing these two dangers ever in mind, seize the portion of the tongue to be extirpated with strong catch forceps and excise it with plenty to spare. We may practise the excision of the whole or only of half the tongue. Arrest the bleeding and draw the edges of the mucous membrane together over the raw surface. The wound is large and should be sutured even in the subject ; *i.e.* the mucous membrane in the floor of the mouth must be drawn together as well as possible ; but it is not entirely closed, for a wide channel is left behind the line of bony suture, enabling the secretions to escape outwards rather than penetrate into the lungs. v. Bergmann even goes so far as to take the movable mucous membrane in front of the tonsil, draw it forward under the jaw and stitch it to the posterior cut surface of the skin ; there is thus for some time a broad fistula leading from the floor of the mouth. Wiring of the bone comes next ; strong wires are passed through the holes already bored (*v.* Fig. 206) and twisted tight with the pincers (Fig. 208). Their ends are bent downwards and can be snipped off at a later date. The various layers of the cheek have to be carefully stitched up in order to provide an adequate covering for the suture line in the bone.

Median division of the lower jaw was first recommended by Sedillot; the method possesses undoubted advantages over lateral sawing of the bone, and it has been recently modernised by Kocher. The first step is a median incision through the lower lip, the chin and the skin of the neck down to the level of the hyoid bone (Fig. 204). The submental muscles are divided by a median incision and holes bored opposite each other in the bone. We then pass Ferguson's needle round the jaw and saw straight through between the two lower central incisors, which we are usually able to preserve. By inserting a pair of single-toothed bone retractors and pulling the two halves of the jaw apart we gain a splendid view of the entire oral cavity. Try to avoid dividing the muscles in the floor of the mouth, for they are inserted

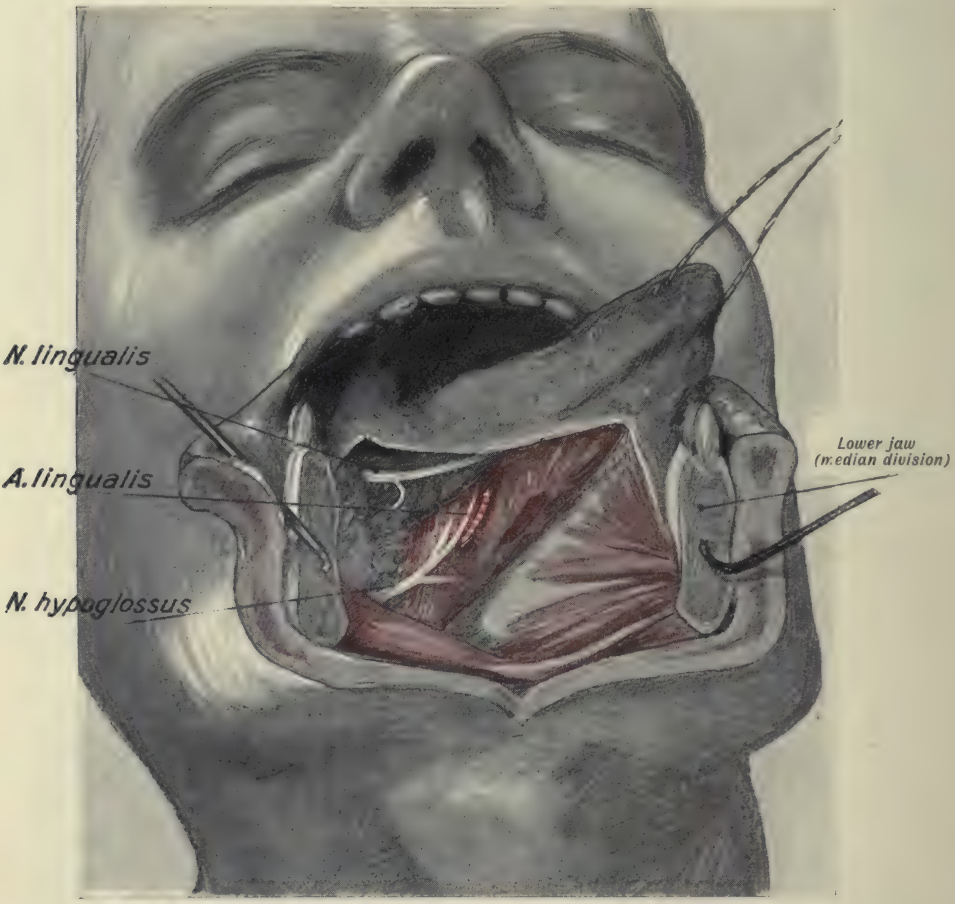


FIG. 209.—Exposure of the tongue with temporary median division of the lower jaw (after Sedillot, with the help of an illustration of Kocher).

into the jaw and are of the highest importance for the after act of swallowing and the prevention of post-operative pneumonia. In total extirpation of the tongue the mucous membrane must be divided along the floor of the mouth and the diseased parts excised along with some of the sound tissue ; in lateral tumours and in hemi-excisions we pull the tongue out of the mouth towards the sound side and examine the side affected. On dividing the mucous membrane of the mouth we come at once upon the lingual nerve ; a little below the lingual we bring the hypoglossal nerve into view, and near the hypoglossal (cp. Fig. 209) we expose and ligature the lingual artery. The further stages of the operation are identical with those of Langenbeck's method, and the floor of the mouth, the divided bone and the soft tissues are to be treated as above described.

9. *Extraction of the Teeth.*

For a correct extraction of the teeth one should carefully examine the necessary instruments. The incisors and canines have straight roots, almost round in cross section ; in extracting them make use of the forceps illustrated on Figs. 210 and 211, the former for the upper, the latter for the lower incisors and canines. The bicuspids (at least the lower ones) have straight roots ; the upper vary somewhat, the roots being either completely divided or partially divided or grooved. The bicuspids are extracted by means of the forceps illustrated in Figs. 210 and 211.

The case of the molars is not so simple. The lower molars have two roots, flattened in the frontal direction, They should be grasped by a forceps, each arm of which is pointed (Figs. 212 and 213). The upper molars carry three roots, two buccal and one palatal ; the same forceps are therefore not available for both sides ; the pointed arm of the forceps should be applied on the buccal side of the tooth. Fig. 214 shows the forceps for the right upper molar, Fig. 215 that for the left upper molar. Lastly, the wisdom teeth are rudimentary structures with one or two roots more or less fused. They are hidden away at the back and should therefore be extracted with special instruments, Fig. 216 for the upper and Fig. 217 for the lower wisdom teeth.

Figs. 218 and 219 represent forceps suitable for the extraction of isolated roots in upper and lower jaws respectively. Universal forceps should on no account be employed. Dental elevators are likewise out of date, for when applied with force they may cause severe fractures to the alveolar process.

The first step in the extraction of a tooth is to choose the proper instrument. Having selected your forceps, apply it loosely to the crown of the

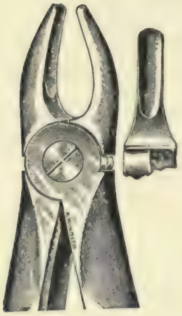


FIG. 210.—Forceps for the upper incisors, canines and bicuspids.

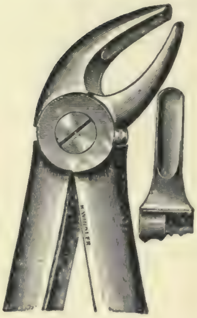
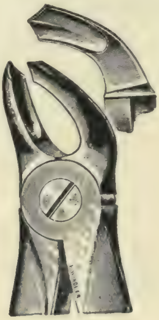


FIG. 211.—Forceps for the lower incisors, canines and bicuspids.



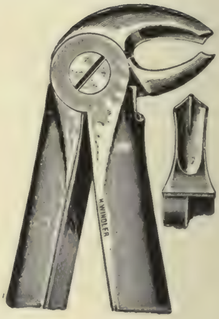


FIG. 212. FIG. 213.
Lower molar forceps.

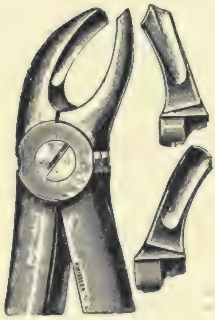


FIG. 214.—Upper molar forceps, right.

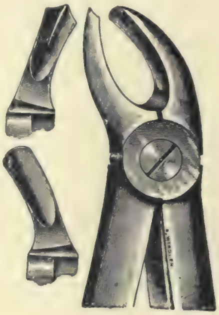


FIG. 215.—Upper molar forceps, left.

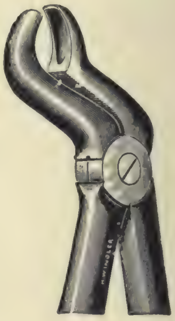


FIG. 216.—Upper wisdom forceps.

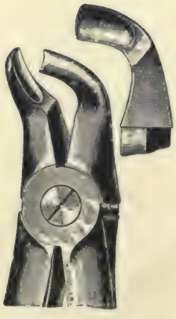


FIG. 217.—Lower wisdom forceps.

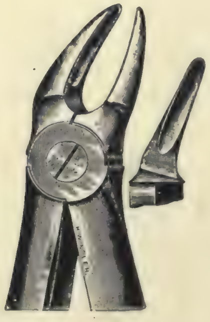


FIG. 218.—Upper stump forceps.

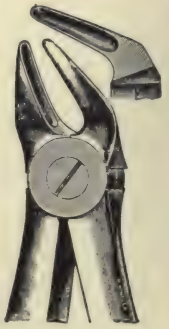


FIG. 219.—Lower stump forceps.

tooth immediately above the level of the gum ; thrust back the gum until the forceps sink deep along the neck of the tooth. It is only then that a firm grip is taken and the luxation movements are commenced—slight levering movements, that loosen the tooth by pressing the crown first towards the tongue and then towards the cheek. Teeth with round roots can be loosened by rotation movements. After the tooth has been luxated completely it should be extracted with a strong pull, care being taken not to twist it over sideways, for the tooth is then apt to break across. This is annoying, for it necessitates reapplication of the forceps or a laborious extraction of the different roots. If a tooth is carious it should not be seized too firmly by the forceps, for the crown being rotten is apt to crumble and after-extraction will then be all the more difficult.

C. Operations on the Neck

1. *Extirpation of the Cervical Glands.*

In operating on the cervical glands we have to differentiate the malignant from the benign cases. When the process is of a simple nature all that is required is to extirpate the gland from the surrounding tissues, conserving all the neighbouring structures. In malignant affections of the glands, on the other hand, we remove the surrounding connective tissue, together with all the contained glands and lymphatics, and obtain a clean dissection of the muscles, nerves and vessels. This last method can be practised with great advantage on the dead subject ; it is entitled to first place among cervical operations, for it offers a splendid introduction to the topographical anatomy of the neck.

If the aim is to avoid the production of scars, several cross cuts in the natural folds of the neck are preferable to a single linear incision. The best example of the transverse cut is Kocher's collar incision. For extirpation of the glands these transverse incisions are made at the side of the neck, *e.g.* Incision *a* in Fig. 220. The intervening flaps of skin can then be raised. A large number of the glands lie immediately below the lower jaw, and they can be excised by means of a horseshoe incision below the bone. A chain of glands is found on both sides of the sterno-mastoid and below it ; for purposes of exploration and operation, therefore, the surgeon has to retract the muscle firmly forwards or backwards. This does not always suffice for free access and we have then to fashion musculoplastic flaps, two of which are illustrated in Fig. 220*b* and *c*. The upper (*b*) divides the skin and then the sterno-mastoid muscle close below its origin from the skull ; the lower (*c*) divides it just above its sterno-clavicular insertion (if necessary the two incisions can be combined). The skin and muscle are then raised as one flap, and a splendid view is obtained of the whole region and a particularly good survey of the cervical vessels. The idea of dividing the muscle right above or right below is to preserve the spinal accessory nerve that innervates it: the nerve slants down from within outwards, passing under the muscle about the junction of its upper and middle thirds and giving off branches in a forward direction to supply it: it then proceeds on to supply the trapezius muscle. To insure the safety of the nerve stem, it is well to expose it before it enters the sterno-mastoid. The glands in the floor of the mouth and in the neck have often to be cleared out in carcinoma of the lips, oral cavity, etc., and the best incision is the one given in Fig. 221. A curved incision is first made along the border of the lower jaw, reaching back on each side on to and beyond the sterno-mastoids, which are to be divided. Two linear incisions are added to the first one on each side, and should be carried at least as far as the crossing-point of the omo-hyoid and sterno-mastoid muscles: the incisions can be enlarged at will. We then reflect the skin flaps on all sides (the lateral as musculoplastic flaps) and make a clean sweep of all the lymphatics. The submaxillary gland is extirpated along with the rest, and this necessitates double ligature and resection of the facial artery. This is a radical clearance, and care must be taken to preserve the hypoglossal, vagi, spinal accessory, descendens hypoglossi and recurrent laryngeal nerves. Preserve also the carotid and

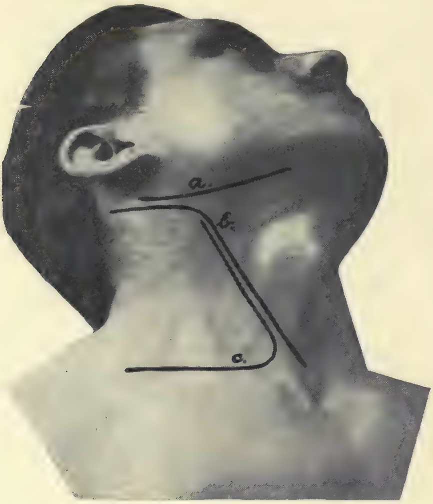


FIG. 220.—Various incisions for excision of the cervical glands (after Pels-Leusden). (*b*) and (*c*) are incisions for musculoplastic flaps.

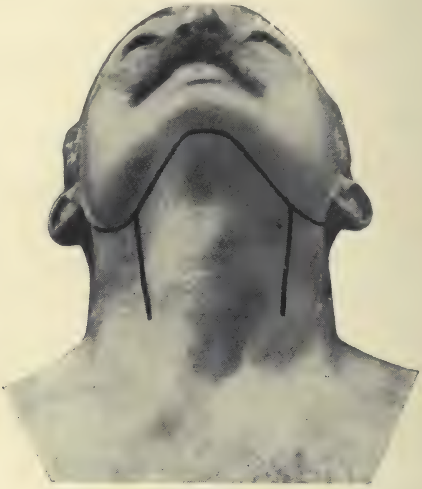


FIG. 221.—Incision for double-sided extirpation of the glands in floor of mouth and neck.

superior and inferior thyroid arteries, and the internal jugular vein, with its main branches. If the surgeon is working in the left supraclavicular fossa, he has to avoid the thoracic duct; it sweeps over the subclavian artery from behind and enters the innominate vein close to the junction of the internal jugular and subclavian veins. Refer to Figs. 21, 22, 207, 222, 232, 234, and 239 before cutting rashly into any of these structures.

2. *Tracheotomy.*

In operations on the larynx and trachea it is well to keep the diagram given in Fig. 222 constantly in mind; the muscles have been removed from the front of the larynx, and the cartilages, ligaments and thyroid gland exposed. The thyro-hyoid membrane extends from the hyoid bone to the upper border of the thyroid cartilage. The two halves of the thyroid cartilage meet anteriorly in the mid line to form the pomum Adami. The thyroid cartilage is connected to the front and sides of the cricoid cartilage by the crico-thyroid membrane. Below the cricoid are a number of delicate tracheal rings. The two lobes of the thyroid gland are joined by the isthmus, which always crosses in front of the uppermost tracheal rings and usually covers a part of the cricoid as well. The isthmus varies in breadth and depth; in the dead subject it is usually avascular and consequently

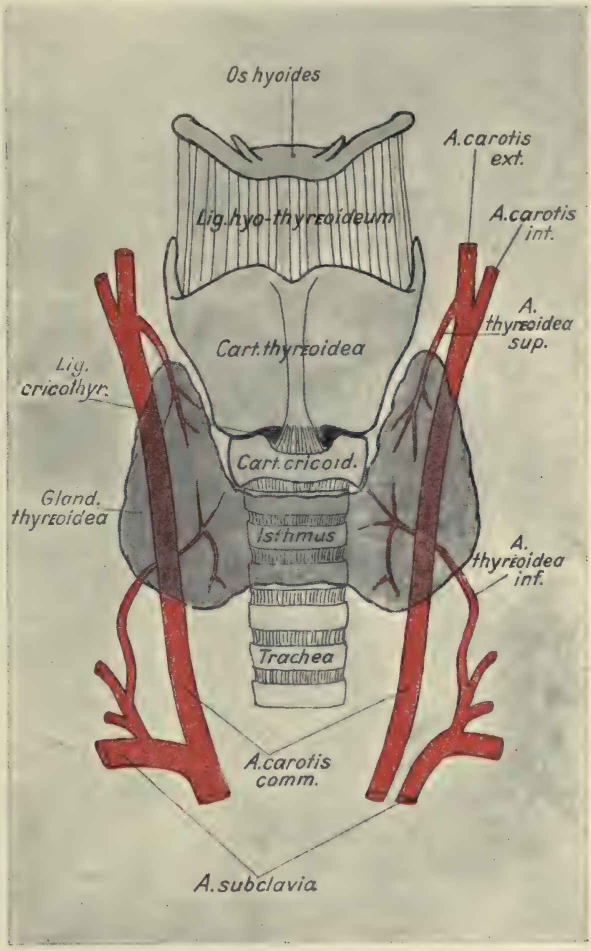


FIG. 222.—Diagram of the larynx, the trachea, the thyroid gland and the arteries supplying it.

collapsed. There is sometimes a prolongation upwards from it, the pyramidal lobe, and this median lobe may be in the way in operations on the trachea and larynx. An exact palpation of the central parts of the neck from the hyoid bone to the suprasternal notch is the necessary preliminary to every operation on these structures. In spare subjects, and especially in adult males, a complete palpation can be made. On bending back the head two structures are seen to jut forwards; the upper corresponds to the upper border of the thyroid cartilage (*thyroid incisura*), the lower corresponds to the cricoid cartilage. This makes it easy to establish the various relations. Palpation is more difficult in the case of women, in people with fat necks, and especially in young children, whose cartilages are so soft that it is often impossible to feel them at all.

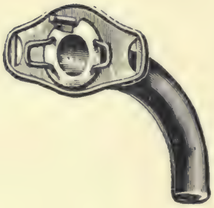


Fig. 223.—Silver tracheotomy cannula. (Double cannula.)

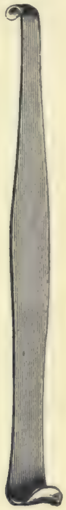


Fig. 224.—Blunt retractor.

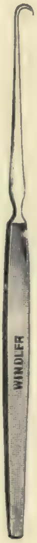


Fig. 225.—Single toothed retractor.

Before attempting tracheotomy you should lay out all the necessary instruments in their order. The special instruments required in addition to the ones in ordinary use are figured in Figs. 223 to 225.

(*a*) *High tracheotomy.*

The aim of the operation is to open the upper two or three tracheal rings with a median linear incision and to introduce a cannula in order to circumvent an obstacle in the upper air passages. For this purpose the isthmus of the thyroid gland should be freed from its firm connection with the trachea and drawn downwards. We absolutely condemn any division of the cricoid cartilage and crico-thyroid membrane because it destroys the basis of the laryngeal apparatus; we hold that the old crico-tracheotomy should be reserved for very exceptional conditions. In all other cases we proceed as given below. The subject lies in the dorsal decubitus with the neck extended backwards. The head must look straight forward. The operator stands on the right side. The incision is made exactly in the middle line; it begins opposite the middle of the thyroid cartilage, is prolonged over the cricoid cartilage and ends 1¼ in. (3 cm.) below it; it is carried through the skin and down to the cervical fascia (*v.* Fig. 226); the beginner should make a somewhat larger cut. The cervical fascia is now divided in the line of the incision; below the fascia there run two longitudinal veins, which anastomose at intervals; make a blunt dissection between them in the middle line, which is here marked by a white streak and retract apart the sterno-hyoid and sterno-thyroid muscles. We are now able to see and palpate the cricoid cartilage with the crico-thyroid membrane inserted into its upper border. The tracheal rings are still concealed behind the isthmus of the thyroid gland. Make a transverse cut and divide the band that binds the isthmus to the trachea and draw the thyroid gland well downwards with the blunt retractor shown in Fig. 224. The trachea is now exposed; insert two fine sharp hooks (Fig. 225) and pull it upwards from below. Make a stab wound between these hooks and open the trachea exactly in the mid line; the cut should be slowly extended till a double cannula (Fig. 223) can be introduced without trouble. The trachea should not be opened till it has been firmly anchored by the three retractors as shown in Fig. 227 and all bleeding has been stopped; otherwise it will slip away into the depths of the wound and there will be grave danger of the blood flowing into the lungs and the patient losing his life before the trachea can be found again. The tracheotomy tube is now introduced; the wound in the trachea should be exactly of the same diameter as the tube itself. To complete the operation the wound should be drawn together with a few sutures above and below the tube.

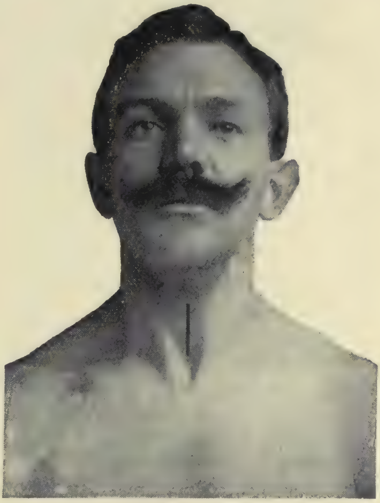


FIG. 226.—Incision in high tracheotomy.

(*b*) *Low tracheotomy.*

By this operation we understand the typical opening of the trachea below the thyroid isthmus. Many surgeons prefer it to high tracheotomy; speaking generally it is the preliminary to major operations on the larynx.

The skin incision in deep tracheotomy starts immediately below the cricoid cartilage and extends down as far as the manubrium sterni. Divide in turn skin, fat and the deep cervical fascia, draw the infrahyoid muscles apart and enter the loose and vascular connective tissue in front of the trachea. Make a blunt dissection through this below the thyroid isthmus. The trachea can now be palpated with the finger, the

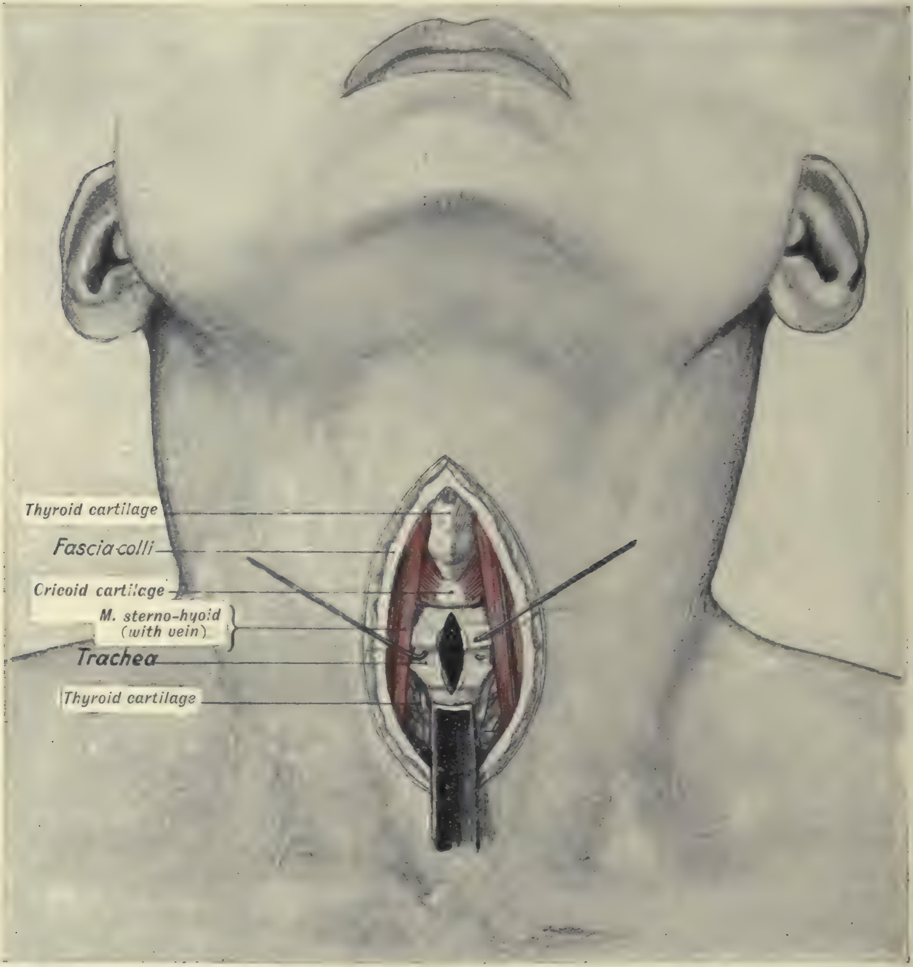


FIG. 227.—High tracheotomy.

deep fascia divided and the trachea drawn out of the depth of the wound with a sharp hook and securely fixed. Open the windpipe and introduce the tube with the same precautions as in high tracheotomy.

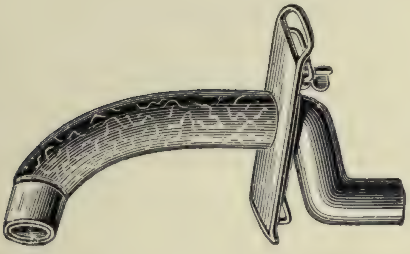


FIG. 228.—Sponge cannula (Hahn).

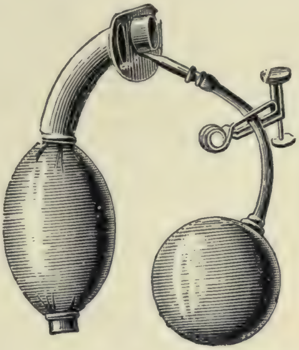


FIG. 229.—Trendelenburg's tampon cannula.

3. *Laryngotomy.*

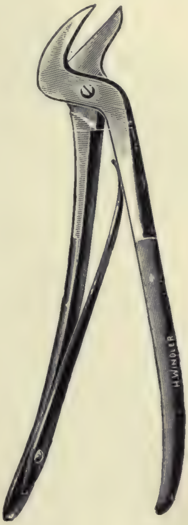


FIG. 230.—Laryngeal scissors.

By this operation we understand a median division of the anterior wall of the larynx for diagnostic purposes and the treatment of disease. The length of the incision will depend upon the nature of the trouble. In order to prevent blood entering the lungs we begin with a deep tracheotomy: but instead of introducing a simple cannula we employ the sponge-cannula (of Hahn) or the tampon-cannula (of Trendelenburg): compare Figs. 228 and 229; the upper part of the air passage is thus hermetically sealed. A median incision is then made: it begins above the thyroid incisura near the hyoid bone and extends downwards as far as the cricoid ring. The incision is carried through all the tissue layers right down to the thyroid cartilage; the point of the knife penetrates the thyro-hyoid membrane at the upper border of the cartilage. Then introduce the laryngeal scissors illustrated in Fig. 230, and divide the thyroid cartilage into two halves, incise the thyro-hyoid membrane in the mid line and if necessary divide the cricoid cartilage. This exposes the true and false vocal cords, and it is possible to treat the arytenoid cartilages and the mucous membrane in any way one likes; for instance, the galvano-cautery might be employed. The divided layers, more especially the cartilaginous parts, are to be accurately coapted with catgut. At the end of the operation a simple cannula is substituted for the tampon-cannula in the deep tracheotomy wound.

4. *Laryngectomy.*

If the larynx is to be totally removed, lay the subject on the dorsum and extend the head backwards. Do a preliminary deep tracheotomy and introduce a screen cannula; in many cases it will be necessary to split up the larynx in order to establish a definite diagnosis. Where the diagnosis is certain and total removal indicated, preliminary tracheotomy is unnecessary; we prefer to keep the air passages shut as long as possible in order to perform an aseptic operation. Make a median skin incision commencing just below the hyoid bone and ending just above the suprasternal notch: divide the skin and the cervical fascia in the mid line of the larynx and retract the infrahyoid muscles apart. Add a transverse incision just below the hyoid bone: this should reach out about 1½ in. (3–4 cm.) on each side. We thus obtain a T-shaped incision (Fig. 231). The transverse cut divides the muscles inserted into the hyoid bone. It is now easy to introduce large retractors and free all the muscular insertions from the thyroid cartilage, partly with the elevator and partly with the knife; in doing so we seize the pomum Adami with catch forceps or a sharp hook and rotate the larynx on its longitudinal axis sometimes to the right and sometimes to the left. The muscles should be raised clean off the perichondrium in order to avoid unnecessary bleeding and keep a sufficient distance away from the carotids on each side. The thyroid isthmus is doubly ligatured with an aneurism needle and divided in the mid line. It is now comparatively easy to raise the two halves of the thyroid gland from off the sides of the trachea and larynx. The separation of the muscles is completed by longitudinal cuts that sever the superior constrictors

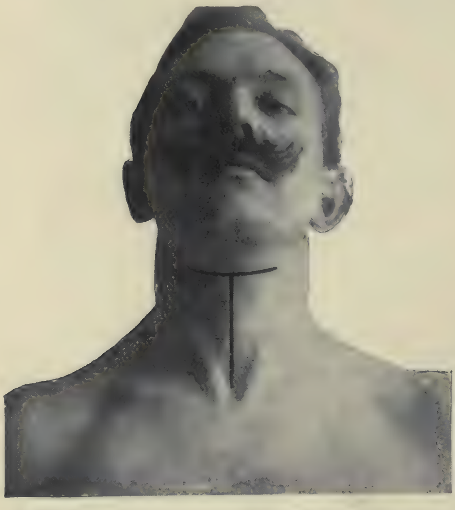


FIG. 231.—T-shaped incision for extirpation of the larynx.

on both sides from the posterior border of the larynx. The operator now divides the trachea just below the cricoid, passes two strong stay sutures through the lower end of the trachea and pulls it forwards. The larynx and cricoid cartilage are drawn forwards and to the side and the posterior wall of the larynx gradually separated from the anterior wall of the oesophagus and pharynx for a good distance upwards; in the course

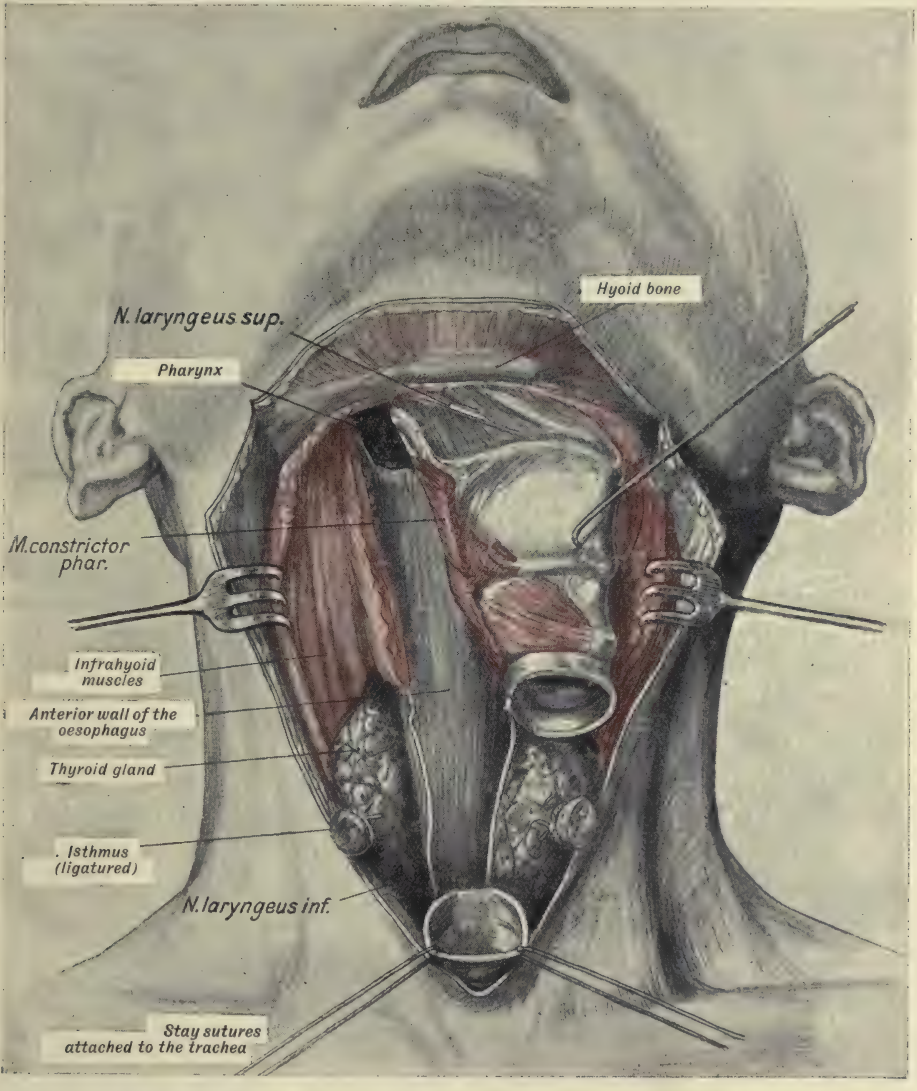


FIG. 232.—Extirpation of the larynx. The T incision divides skin, infrahyoid muscles and the thyroid isthmus; the larynx has been freed and the trachea divided; the pharynx has been opened in the upper part of the wound.

of this the recurrent laryngeal nerves are divided ; to avoid opening into the gullet we adhere closely to the larynx. It is only at the level of the false vocal cords that the pharynx is entered. Fig. 232 represents this stage of the operation. The operator then completes the extirpation by cutting across the thyro-hyoid membrane just below the hyoid bone ; the superior laryngeal nerves and vessels are divided in the process. The epiglottis should be pulled from the pharynx down into the wound by means of a retractor or by introducing a finger : it is then cut away at its root. This gives us a very large wound with the stump of the trachea held anchored by the sutures at its lower angle. Stitch the lips of the stump into the lower angle of the wound ; in the upper angle of the wound stitch up the mucous membrane of the gullet to the hyoid bone till only an opening the size of a sixpenny piece is left in the anterior pharyngeal wall. A rubber tube is introduced through this into the stomach. The wound cavity is partially closed, but part of it is packed and left open. Another way of treating the wound is to loosen the tracheal stump, draw it upwards and do a circular anastomosis between it and the upper laryngeal ligaments going to the epiglottis. The continuity of the air passages can thus be re-established.

Extirpation of half of the larnyx is performed in a similar way and on the same principles of after treatment. Perform deep tracheotomy, carry out laryngotomy and then proceed to remove the one half of the larynx.

5. *Pharyngotomy.*

The various methods of pharyngotomy form an important chapter. They afford access from the neck to the different parts of the pharynx. They are modified to suit the various requirements, but the aim in all of them is to gain as good access as possible without injuring the neighbouring structures.

The most important method is that of subhyoid pharyngotomy (after v. Langenbeck). The attack is made below the hyoid bone and the pharynx is opened transversely between the root of the tongue and the epiglottis. It is eminently suited for tumours of the epiglottis, arytenoid cartilages and lower part of the pharynx ; it also exposes the base of the tongue. Bend the head over backwards, with the face looking straight forwards. Tracheotomy and the introduction of a tampon cannula are not absolutely necessary if we only prevent the blood from entering the larnyx during the whole operation, and they are quite superfluous in local anaesthesia, for the adrenalin in the solution contracts the blood-vessels and renders the tissue anaemic.

The skin incision runs horizontal just below the hyoid bone from the tip of the one great cornu to the corresponding point on the other side (*v.* Fig. 233). The hyoid bone is exposed, seized in the mid line with a sharp hook and pulled upwards. The layers of the infrahyoid muscles (sterno-hyoids, omo-hyoids and thyro-hyoids) are divided at their attachments to the hyoid bone, and all the bleeding points ligatured. We then divide the layer of fat that lies on the thyro-hyoid ligament and reach the ligament itself (*v.* Fig. 222). Divide it close up to the hyoid bone, thus preserving the superior laryngeal nerve on both sides: these run obliquely downwards and inwards, and enter the larynx by piercing the thyro-hyoid ligament (cp. Fig. 232); their division leads to anaesthesia of the laryngeal mucous membrane and is a factor in the production of aspiration pneumonia. The mucous membrane should be opened exactly between the epiglottis and the base of the tongue. The exact spot can be located by passing the forefinger of the left hand into the mouth and pressing forwards the membrane between the root of the tongue and the epiglottis. The exposure is completed by the transverse division of the pharyngeal wall (*v.* Fig. 234). Seize the edges of the mucous membrane with Mikulicz forceps, introduce a pair of blunt retractors at the angles of the wound and exercise firm retraction on the wall of the pharynx, which yields readily; the epiglottis should then be drawn down out of the wound. Kocher advises the use of the thermocautery for excising the diseased parts. Suture up the openings in the mucous membrane as well as possible; if there are any defects perform tracheotomy and tampon the wound. The wound in the mucous membrane should be completely sutured whenever possible; on the other hand, the wound in the musculature and skin is closed only at the sides, leaving the rest of it to be packed, as the tissues have been already infected from the pharynx. Subhyoid pharyngotomy can be combined with lateral pharyngotomy. The latter method allows of a complete survey of the entire hypopharynx, laryngeal opening and commencement of the oesophagus, but very thorough access to the part can be obtained simply by a median division of the hyoid bone.

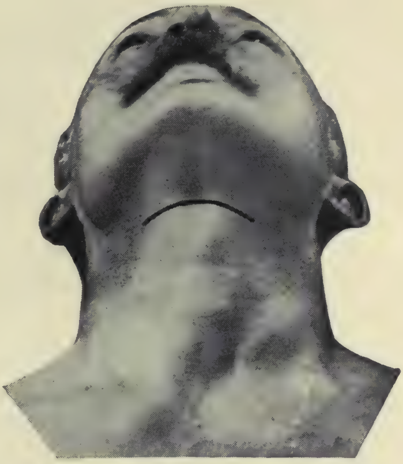


FIG. 233.—Incision for subhyoid pharyngotomy.

Kocher describes a combination of subhyoid pharyngotomy with a large median incision passing downwards, followed by partial excision of the larynx ; he calls the method mediolateral pharyngectomy.

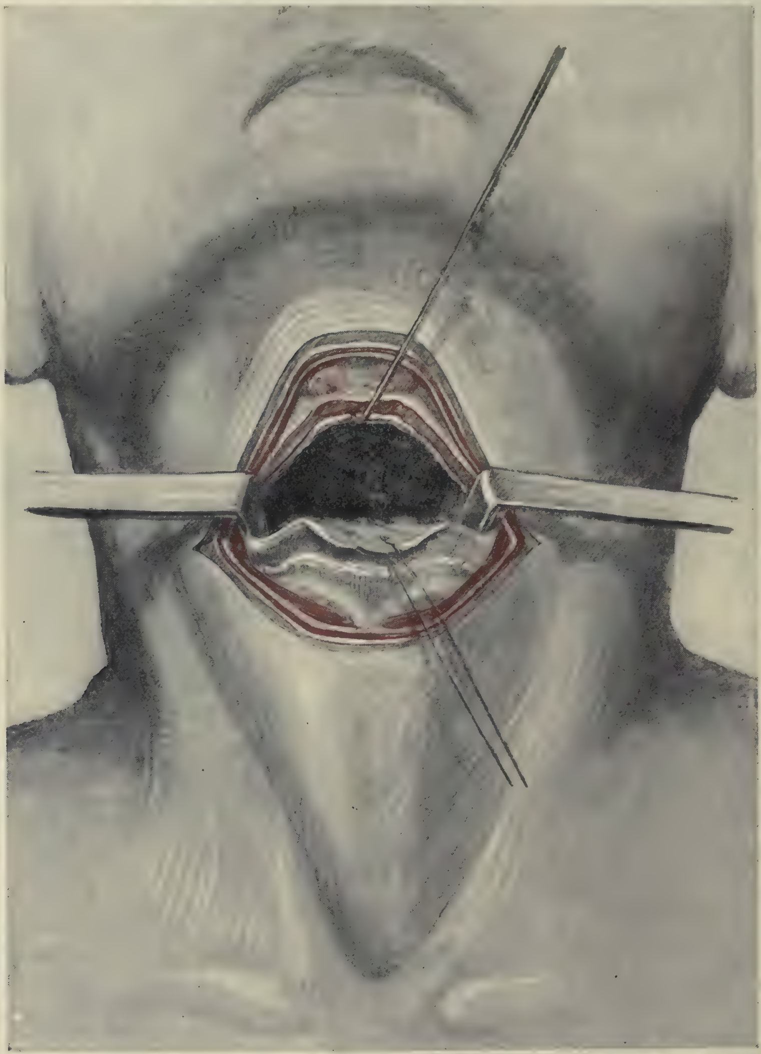


FIG. 234.—Subhyoid pharyngotomy. The hyoid bone is drawn up with a sharp hook and the wound retracted out with a pair of blunt ones ; the epiglottis is drawn out with a suture.

Suprahyoid pharyngotomy is not so important as the subhyoid method. The skin incision is made somewhat higher than in subhyoid pharyngotomy. Then divide the muscles reaching up from the hyoid bone to the chin and tongue, displace the hypoglossi nerves to each side, free the digastric muscle at its tendinous attachment to the hyoid bone (being careful to preserve the lingual artery on each side, cp. Fig. 22 in Chap. I.) and open the mucous membrane of the pharynx ; to do this pass the finger into the mouth and press forward between the base of the tongue and the epiglottis. Median division of the hyoid bone can be added also in this operation. Extend the head well backwards, force open the edges of the wound with blunt retractors and pull the root of the tongue forwards and upwards. This exposes the entire mesopharynx and epipharynx. The diseased parts are to be excised and the wound treated exactly as in the subhyoid operation.

The incision for lateral pharyngotomy is shown in Fig. 235. A longitudinal opening is made in the pharynx and upper part of the oesophagus, while the larynx and the structures belonging to it are displaced to the opposite side. The extent of such a pharyngotomy depends not merely on the seat and size of the tumour to be removed, but also on the richness of the fatty envelope in the neck. When the neck is long and thin we experience no difficulty in obtaining a good view of the pharynx, but in people with short fat necks the difficulties and dangers of the operation are greatly enhanced and our survey is necessarily restricted. The question of preliminary tracheotomy must be decided on the individual merits of each case. The incision runs from below the middle of the horizontal ramus down to the level of the cricoid cartilage, where it ends about the anterior border of the sterno-mastoid muscle (cp. the linear incision in Fig. 235). The operator proceeds at once to extirpate the glands, including the submaxillary as it lies below the lower jaw ; he then ligatures the facial artery, divides the muscles covering the lingual artery and ligatures it, and then ligatures the superior thyroid artery and the anterior facial vein. The superior laryngeal nerve must now be sacrificed if the pharynx is to be exposed in its whole extent ; having thus exposed the lateral wall of the pharynx, pass a thick metal sound from the mouth, push forward the pharyngeal wall into the wound and incise. The whole operation is very

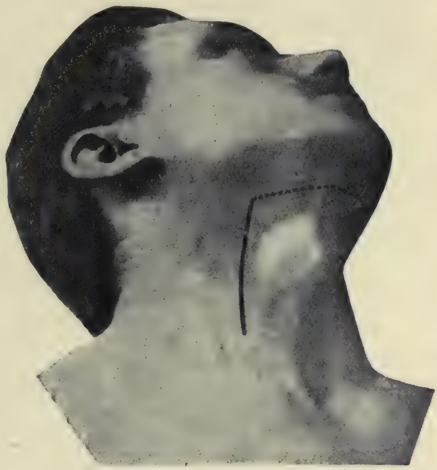


FIG. 235.—Incision for lateral pharyngotomy ; the dotted line indicates how subhyoid pharyngotomy can be added.

comparable to oesophagotomy (to be described next) and the principles of after treatment are identical with those of other pharyngotomies. When we are forced to resect the oesophagus in continuity, it is often difficult to suture up and cover in the defect; in these circumstances we stitch a feeding tube into the lower end of the oesophagus and suture the tube to the skin of the neck. We have once again to caution the reader against stitching up the wound in the skin too closely. The lower jaw may have to be sawn through if we cannot secure sufficient access in an upward direction; but it is preferable to tack on a forward incision as in subhyoid pharyngotomy (cp. the dotted line in Fig. 235), and after dividing the various structures as in subhyoid pharyngotomy to pull the larynx well forwards, thus obtaining a wide survey of the field of operation.

6. *Oesophagotomy.*

In opening the oesophagus it is best to attack it from the left side, for it inclines somewhat to the left about the level of the lowest cervical vertebra and is thus more easily accessible from that side. Bend the head backwards and turn it to the right. The skin incision resembles the one in use for the exposure of the common carotid and inferior thyroid arteries (*v.* Fig. 22); it runs along the anterior border of the sterno-mastoid muscle, dividing skin and platysma, and extends from the upper border of the thyroid cartilage to the suprasternal notch. Expose the edge of the sterno-mastoid in the line of the incision and retract it firmly outwards. This exposes the vertical infrahyoid muscles (sterno-hyoid and sterno-thyroid), which should then be drawn forward. We now come upon the deep cervical fascia, covering in the great vessels of the neck. Make a linear cut into this fascia and expose the common carotid artery with the internal jugular vein to its outside; insert blunt retractors and displace the vessels backwards and the lateral lobe of the thyroid gland forwards. We now work inwards at a considerable depth. The omo-hyoid muscle runs obliquely across the field of operation, and it should be divided at once in order to allow free access. In regard to the larger branches of the carotids and internal jugular, the facial vein can usually be drawn upwards out of the way of the knife, but the inferior thyroid artery should be doubly ligatured and divided: it is seen in Figs. 22 and 222. As in ligature of the inferior thyroid artery we have to bear in mind the position of the inferior (recurrent) laryngeal nerve (*v.* Figs. 22 and 236): it crosses behind the artery and runs upwards. Its relations with the larynx and trachea should be left undisturbed; it should be drawn forwards along with these structures.

The oesophagus now comes into view as a flattened tube running down between the trachea and the vertebral column. It is recognized by its longitudinal muscle and its rosy-grey colour. Fix it with a pair of forceps and make a linear cut through the muscular and thick mucous coats and catch up the edges of the wound with stay-threads or Pean's forceps. This stage is represented in Fig. 236.

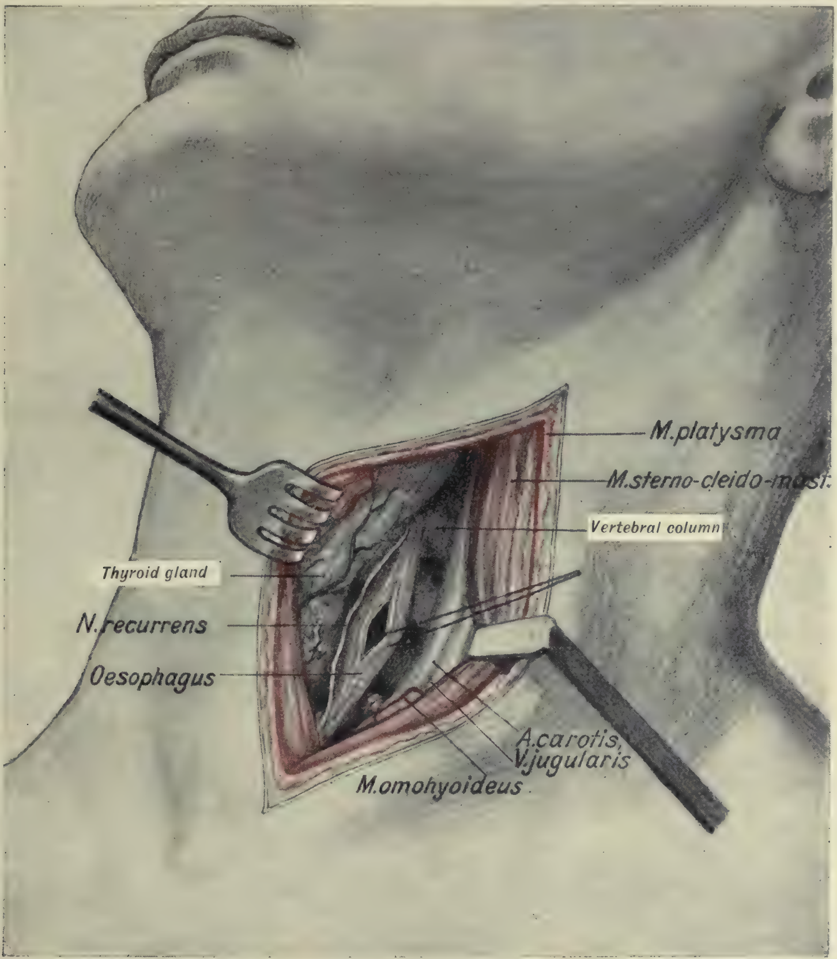


FIG. 236.—Oesophagotomy. Thyroid gland, recurrent nerve and trachea are pulled forwards; sterno-mastoid and large cervical vessels outwards. An opening has been made in the oesophagus, which is seen resting on the vertebral column.

If there be any difficulty in finding the oesophagus by the typical method, it will greatly faciliate matters to pass a thick rubber tube into the mouth. In closing the wound in the oesophagus the mucous and muscular coats should be stitched independently of each other. As the suture is usually somewhat insecure the rule is to leave the outer wound open and to perform a secondary closure.

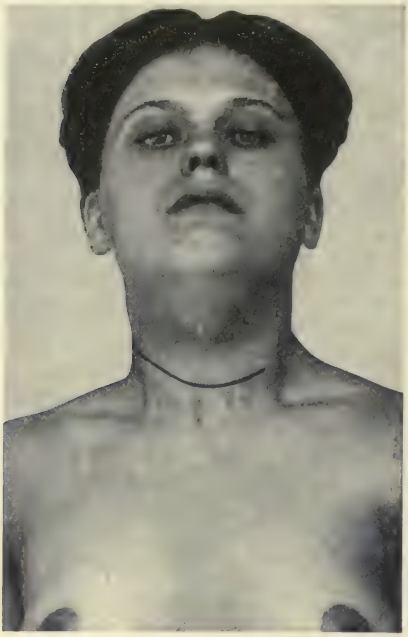


FIG. 237.—Kocher's incision for excision of the right lobe of the thyroid gland. (Collar incision.)

7. *Thyroidectomy.*

We notice from the diagram in Fig. 222 that the thyroid gland has a somewhat horseshoe shape when viewed from the front. The two large lateral lobes are joined by an isthmus, which is usually small: posteriorly they envelope the trachea and the lower portion of the larynx on both sides. The thyroid is firmly united to the trachea and accompanies it up and down in the act of swallowing. It is a ductless gland. It is supplied by four large arteries which are seen in Figs. 222 and 239; the superior thyroid artery arises from the external carotid on each side and the inferior thyroid artery runs upwards from the subclavian artery and then turns inwards to reach the gland. All these arteries are accompanied by veins; in addition, large veins leave the lower poles of the organ and pass downwards. In the surgery of this gland the inferior laryngeal (or recurrent) nerve is of the utmost importance; it is shown in Figs. 22 and 236; it runs up to the larynx on both sides, lying in the angle between trachea and oesophagus; the inferior thyroid artery crosses it in a critical part of its course, shortly before it enters the thyroid gland. The parathyroid glands are small bodies lying in the posterior capsule of the thyroid lobes; they must be avoided just as carefully as the recurrent nerve, for if they lose their function through injury or unintentional removal tetany will ensue. The thyroid itself should never be entirely removed; at least a quarter of its normal tissue should be retained, or else the condition of cachexia strumipriva will follow.

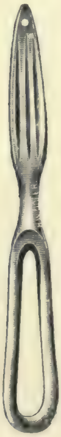


FIG. 238.—Kocher's thyroid spatula.

The operations on the thyroid are very numerous, but not more than a few can be practised on the subject. The technique for the typical ligation of its main arteries was given in Section I. We should now practise the most important of all thyroid operations—unilateral excision of the gland.

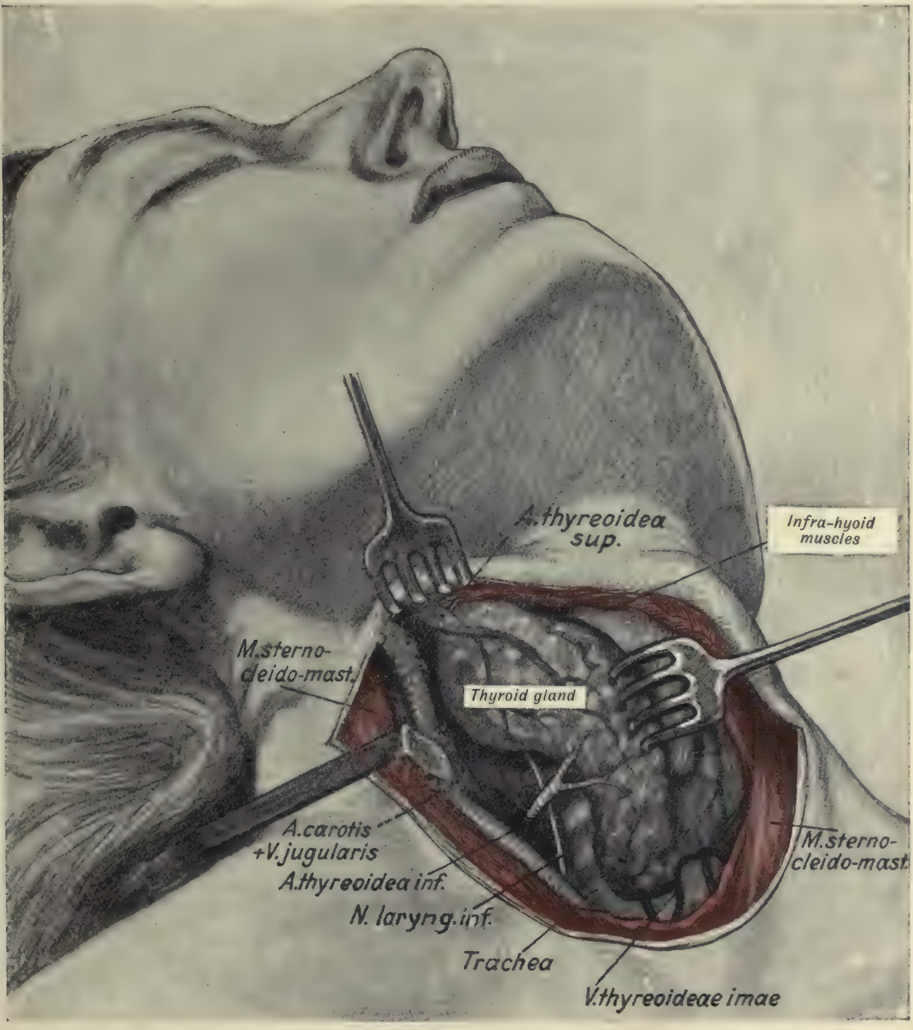


FIG. 239.—Excision of the thyroid gland (Kocher). The right lobe has been raised, and the superior and inferior thyroid arteries put upon the stretch; the recurrent nerve is visible.

Formerly oblique incisions used to be made at the anterior border of the sterno-mastoid, until Kocher taught the now universal collar incision, represented in Fig. 237. His directions for thyroid operations are taken as the standard in Bier's clinic. The incision is made at the level of the cricoid cartilage: it is a slightly curved transverse incision that crosses the middle line from the outer side of one sterno-mastoid muscle to the other. For unilateral excision the incision can be made shorter on the sound side. Divide the skin, the platysma and the superficial layer of the cervical fascia, and attend to haemostasis. Reflect the divided skin and fascia upwards and downwards, raising the flaps from off the muscles which cover the thyroid swelling; this is the best way of separating the tissues, because the veins that run in the fascia will not need to be divided more than once. If the goitre is a small one it is now possible to penetrate between the straight muscles of the neck by means of blunt separation; but it is usually found that these muscles (sterno-hyoid, sterno-thyroid and omo-hyoid) are spread out in the form of a broad curtain and require to be divided, at least on the affected side. Behind the muscles and between them and the capsule of the gland there is a layer of loose connective tissue and this must also be divided. The firm capsule covering the thyroid gland now comes into view: during life it carries many vessels rich in blood. In separating the soft tissues from the capsule and also in isolating the principal vessels we shall find Kocher's thyroid spatula of great value (Fig. 238). Never divide the sterno-mastoid on the affected side, but draw it outwards with blunt retractors. Dissect bluntly round the side of the gland and displace it forwards, ligaturing and dividing any vessels encountered. The picture thus got is shown in Fig. 239. The gland has been elevated, but is still firmly anchored at the isthmus and by its principal vascular connections. Next pull the upper pole of the gland well forward and ligature the superior thyroid artery and vein with a stout double ligature; this important vascular stalk is then divided. Throw the thyroid over to the sound side and direct attention to the inferior thyroid artery; the trunk of this artery should be ligatured, but it is not divided till we are sure of the position of the recurrent nerve. Now raise the lower pole of the lateral lobe. This puts the pretracheal plexus of veins on the stretch: ligature them off in bundles. This frees the lateral lobe completely and we now turn to the isthmus; carefully introduce the spatula between it and the trachea, separating the two completely; then take a Kocher's thyroid clamp (Fig. 240) and crush the substance of the isthmus. The isthmus should then be ligatured and divided. It is now easy to make a bloodless separation of one-half of the gland from the isthmus outwards. In order to preserve the parathyroid

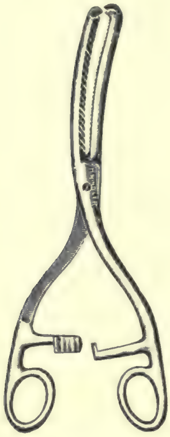


FIG. 240.—Kocher's clamp for thyroidectomy.

glands and the recurrent nerve the posterior capsule and especially that part of it that lies against the trachea should be retained together with some of the glandular substance. The operation is completed by arresting the bleeding, suturing the divided muscles, allowing for drainage and stitching up the skin.

SECTION VI

OPERATIONS ON THE BREAST AND TRUNK

1. *Amputatio Mammae.*

THE opening of breast abscesses and the excision of benign tumours cannot be practised on the dead subject. In these minor operations the nipple should be preserved, and radial incisions are the rule : this prevents needless injury to the numerous milk ducts.

Excision of the entire mammary gland is nearly always performed on account of malignant tumours. The axilla must always be cleared out at the same time.[1] The double operation can be practised on the dead subject with the greatest advantage, and runs as follows : Place the subject on the dorsum at the edge of the table, raise the shoulder a little on the affected side, and let the assistant abduct the arm to more than a right angle from the body. The operator stands facing the axilla, with one assistant standing above the arm at the shoulder and another on the other side of the body. The operator palpates the insertion of the pectoralis major into the humerus, and with a few superficial cuts with the tip of the knife marks out his intended skin incision, so that he may be able to carry the knife firmly and smoothly into the subcutaneous fat. In amputation of the right breast the incision begins at the insertion of the pectoralis major into the humerus, runs through the axilla at the lower border of that muscle, curves round the nipple some two or three finger-breadths below it, and ends a little way from the ensiform process of the sternum. A second incision is made from the first one at or near the anterior axillary line, and is carried above the nipple and equidistant from it to join the first incision at its termination. We thus get an elliptical flap of skin which includes the middle of the breast and the nipple: the latter comes away later with the breast. This typical incision is shown in Fig. 241. The seat of the disease often makes it necessary to alter the line of the incision, and if the skin is implicated we are obliged to condemn still more of it in an upward or downward direction. The skin must now be reflected upwards and downwards in the form of two flaps as far as the periphery of the gland; but the glandular tissue is not marked off in any way from the fat with which it blends, and it is not easy to recognize the fine glandular processes in the case of old women with atrophic glands; it is therefore better to reflect the flaps too much than too little. It is only now that the pectoral fascia is reached in the line of the upper incision; lift the skin and fat off the muscle until the furrow is reached that marks the interstitium between its sterno-costal and clavicular portions. Separate the muscle fibres with the back of the knife almost as far as the humeral insertion, while the assistants draw up the skin with large retractors. The lower part of the muscle is now divided at the humeral insertion and the main portion of the muscle (the sterno-costal part) is excised along with the mammary gland. Set the knife flat, and with long sweeps strip all the muscular fibres from the sternum and ribs, taking care to avoid doing injury to the intercostal muscles and pleura. On the pectoralis major being raised the pectoralis minor is exposed in its whole extent; it is much smaller than the major, and is recognized by the obliquity of its fibres as they converge to be inserted into

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[1] The lymphatic paths from the mamma fall into three groups :—

(1) Principal : The main path is to the pectoral group of glands along the outer border of the pectoralis minor, thence to the axillary and supraclavicular glands.

(2) Accessory : The path to the subclavicular and mediastinal nodes (patent in a small percentage of anatomical subjects).

(3) Collateral : Compensatory paths may be opened up when other ways are blocked by disease, *e.g.* over the skin of the chest to the other mamma or axilla, or even over the abdomen to the inguinal glands.—TR.

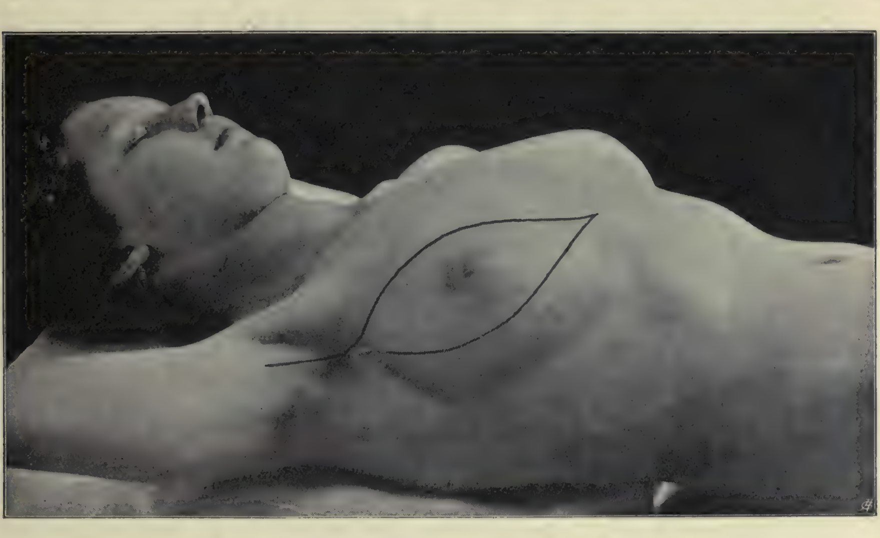

FIG. 241.—Incision for amputation of the breast.

the coracoid process. Expose the outer edge of the pectoralis minor in its whole length; in advanced cases of breast cancer the minor must also be removed. We have still to delimit the posterior boundary of the axilla by exposing the free edge of the latissimus dorsi muscle; we therefore lift the mammary gland from off the interdigitations of the serratus magnus. The gland and the excised part of the pectoralis major are now attached only by the axillary fat and connective tissues and we proceed to the second part of the operation, the clearing out of the axilla.

The first step is to expose the axillary vein. This is usually a large single trunk, but it is often found as two branches: the vein lies superficial to the nerves and the other vessels of the axilla. It is easily found at the lower edge of the coraco-brachialis muscle (cp. Ligature of the axillary, Fig. 24). Clear it of its surrounding fat, taking care not to injure the adventitia, and expose it as far as the lower border of the pectoralis minor. It is surrounded by the nerves of the brachial plexus. A number of tributary veins enter it from the axillary fat, the largest and most important of which is the subscapular vein: it accompanies the subscapular artery. For a thorough removal of the fatty and glandular tissue we require to double ligature and divide all the venous and arterial branches. We are thus able with the help of the scissors and dissecting forceps (partly by sharp, partly by blunt dissection) to secure an anatomical preparation, as is shown in Fig. 242. We should endeavour, if the extent of the carcinoma allows it, to preserve two important nerves: they arise from the brachial plexus and are seen in the diagram; the subscapular nerve lies near the subscapular vein and gives off numerous twigs to the subscapular, teres major and latissimus dorsi muscles; the long thoracic (or respiratory nerve of Bell) which appears from under the pectoralis minor, runs longitudinally on the thorax and supplies the serratus magnus muscle. Next insert a blunt hook under the pectoralis minor and follow the vein far up into the subclavicular fossa. Ligature all the vessels that are met, and remove all the fat and lymph glands embedded therein; when the glands are palpable above the clavicle in the supraclavicular fossa, it is often possible to draw them down at this point and extirpate them. Finally bore a hole through the latissimus dorsi from the wound, cut a small hole in the skin, and draw a drainage tube the thickness of the little finger into the axilla close to the axillary vessels. This is intended as a channel for any after bleeding, but, nevertheless, every vessel should be ligatured with care before being divided. Unite the edges to form a linear scar. The anatomical picture that we get prior to the skin suture is given in Fig. 242.

In very advanced cases we may divide the pectoralis minor or even saw through the clavicle in order to gain a readier access to the supraclavicular glands; we may also remove the pectoralis minor. If the carcinomatous glands have grown on to the axillary veins we may do a partial resection of the vessel, followed by circular suture, or we may resect in continuity and do a circular anastomosis. A wide removal of the carcinomatous skin often leaves such a large gap that the edges of the wound cannot be approximated

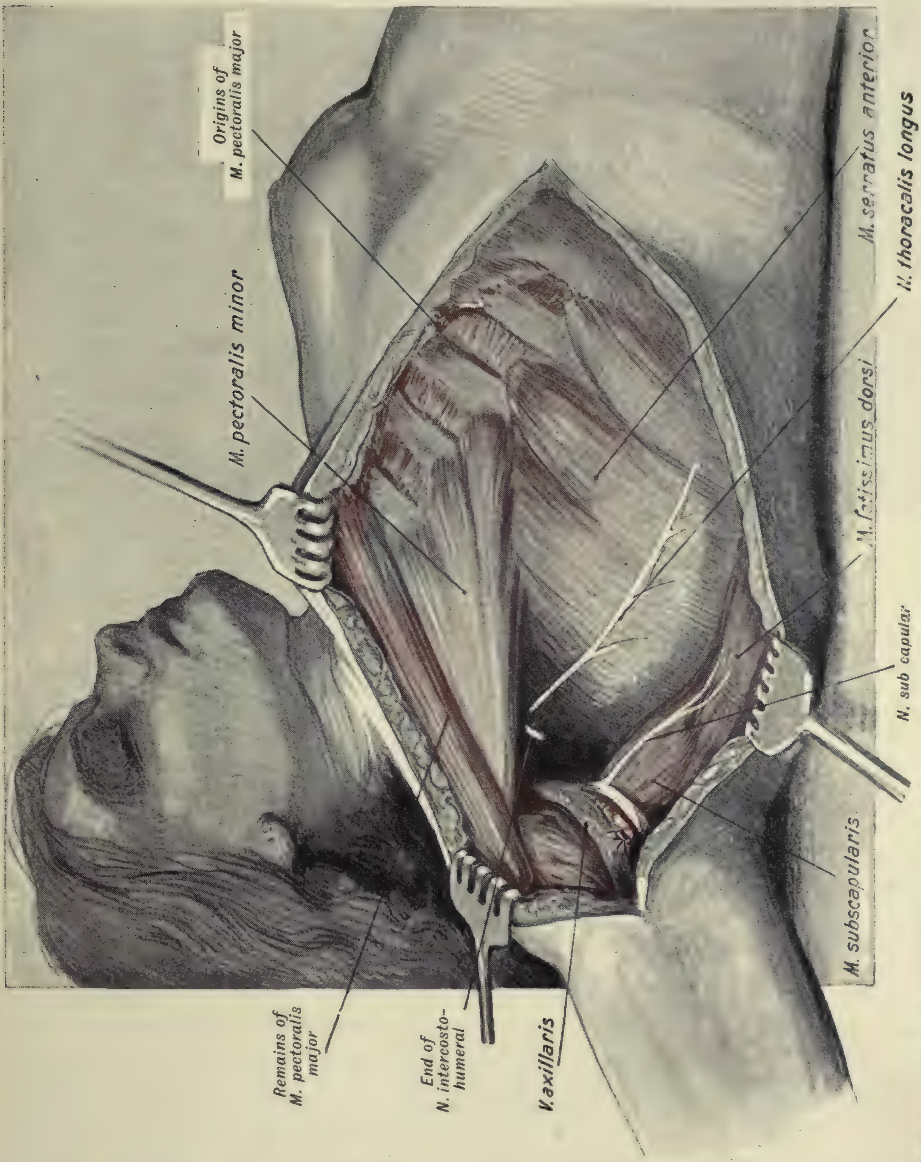

FIG. 242.—Amputatio mammae. The diagram depicts the final stage of the operation prior to the suture of the skin. The skin and part of the pectoralis major have been removed along with the mamma, and the axilla has been cleared out.

and we are forced to use Thiersch's skin-grafts. Various plastic methods may also be taken into consideration. Kocher in operating for mammary carcinoma has a preference for the incision shown in Fig. 243. It begins at the middle of the clavicle and runs thence to the anterior axillary fold. It passes obliquely through the axilla. The method provides good access to the pectoral insertions and affords a good view of the axilla. The excision of the gland itself is performed exactly as above described. If we are obliged to condemn a very large area of the skin, the incision may sometimes be planned with a view to plastic suture.

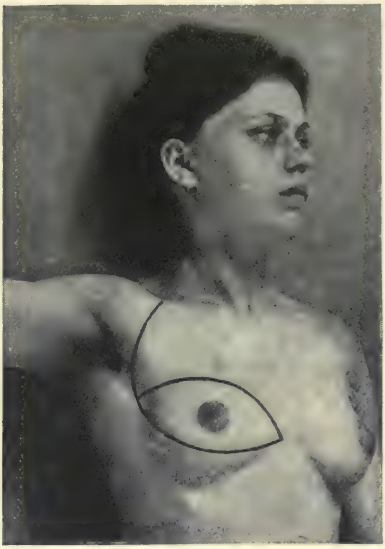

FIG. 243.—Kocher's incision for amputation of the breast.

2. *Resection of a Rib.*

The ribs are removed sometimes on account of disease in the bone itself, and sometimes in order to procure access to the thoracic contents. On the dead subject it is best to begin with a simple resection of a rib, and it is well to choose the lateral or posterior wall of the chest. One should have recourse to a skeleton and recall to mind the oblique curved course of the ribs. Carefully palpate the outlines of a rib with the finger and thumb of the left hand, and make a 3-in. (about 8 cm.) incision along its outer surface, dividing the skin, fat, superficial muscles of the thorax and the periosteum of the rib. It is now easy to strip up the periosteum from the rib all round; in doing so we should recollect the shape of a rib in transverse section. Fig. 244 shows how the intercostal artery and vein lie under cover of the lower border of the rib where they run in a furrow, well guarded from external injury. This furrow is particularly well marked and the lower edge very sharp in the dorsal portion

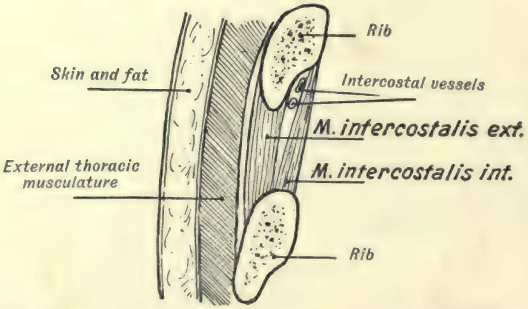

FIG. 244.—Diagrammatic section of a rib, showing the position of the intercostal artery.

of the rib; in the ventral portion the vessels are not so well guarded, for they lie more to the lower border of the rib and are apt to be caught by external trauma below the rib. In puncturing through the front of the thorax, therefore, always adhere to the upper border of the subjacent rib. Fig. 244 also shows the origins and insertions of the external and internal muscles, with the vessels lying between them: the vessels are accompanied by the intercostal nerve. In stripping up the periosteum we have to bear in mind the form of the rib, the firm attachment of the intercostal muscles to the periosteum at its lower edge and the position of the intercostal vessels. The separation is effected by elevator and raspatory; we employ strongly curved instruments (*v.* Figs. 245 and 246) for the posterior surface. The costal pleura should be preserved, and as it is closely applied to the inner periosteum the greatest care must be exercised. In the living subject we have often to deal with a much thickened periosteum or pleura; there is thus no danger of opening into the pleural cavity accidentally. Having exposed the rib as far as is desirable for resection purposes, introduce a costotome (*v.* Fig. 247) under the rib, and divide it first at one side and then at the other; this brings the thin wall of periosteum and pleura into view between the two ends of the bone. This simple and typical operation should be carefully practised on the subject, for though the number of ribs resected is very variable it is the fundamental operation in the surgery of the thorax (Fig. 247).

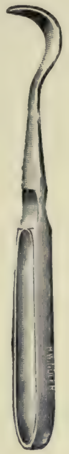

FIG. 245.—Strongly curved elevator.

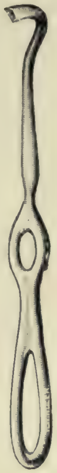

FIG. 246.—Strongly curved raspatory.

3. *Thoracotomy and Resection of the Thorax.*

The cavity of the chest is opened on account of empyema and for the exposure of the thoracic contents. An empyema can be evacuated either by means of puncture or by a simple incision into the chest (thoracotomy). The incision should run exactly parallel to the course of the ribs, but in an intercostal space. Carefully divide all the different layers—skin, fat, thoracic muscles and the two layers of the intercostal muscles. Injury to the intercostal artery can be prevented by adhering to the upper border of the rib, or at any rate by not going too near the lower border. The last structures to be divided in opening the pleural cavity are the endothoracic fascia and the lining parietal pleura. This way of opening the chest affords a minimum of space, and is not generally employed except in the empyemas of childhood. In the adult we make a window in the rib, *i.e.* we resect in the way

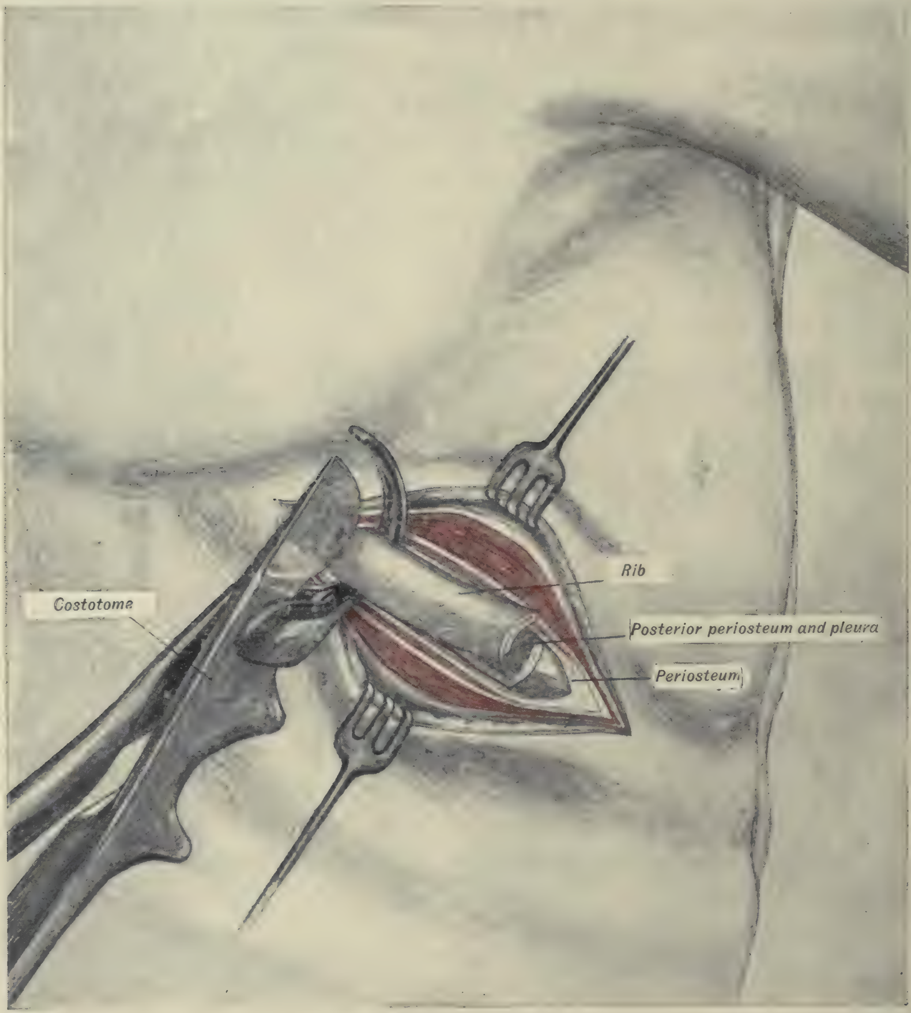

FIG. 247.—Resection of a rib. The soft tissues having been reflected the rib is excised with the costotome.

described above (Fig. 247) taking away a piece of rib about 1¼ in. (3 cm.) long. Divide the layer of periosteum and pleura in the same line as the rib, and thus obtain a large opening for drainage. We should practise counting down the ribs in the subject, for thoracotomy and the establishment of a window in the chest wall are carried out in large empyemas at a quite definite point; we desire of course to choose a low spot, one that will be favourable to drainage, but we must not go too low and invade the complemental space; the diaphragm is then apt to glue against the opening and block it up. Resection is usually performed at the seventh or eighth rib in the posterior axillary line; always do a preliminary puncture in the living subject.

In old standing empyemas we resect all the ribs that cover the chronic abscess cavity. Schede goes the furthest in this respect; he perfected the methods of thoracoplasty by adding a special incision for empyemas affecting the entire pleural cavity. This large incision is shown in Fig. 248; it commences in front near the edge of the sternum and terminates behind at the tubercules of the ribs; a large flap of all the soft tissues is thus formed with its base upwards, and this allows the scapula to be turned upwards with it. We next perform a subperiosteal resection of the ribs that cover in the empyema cavity, excising them one after another, and force the soft tissues upwards. This gives the large cavity a chance to heal up. Bier is in the habit of making a similar incision through the skin and muscles, but he then introduces a saw (cp. Fig. 249) and divides the ribs and pleura at the anterior and posterior edge of the empyematous cavity. The method can easily be practised on the subject. It shortens the troublesome process of resecting one rib at a time, and there is not so much bleeding, as the action of the saw on the intercostal vessels is such as to prevent it. A considerable part of the chest wall is removed in an upward direction and also a portion of the angle of the scapula. The flap of skin and muscle is then applied to the surface of the lung. The posterior and lower part of the wound is drained and the skin carefully sutured.

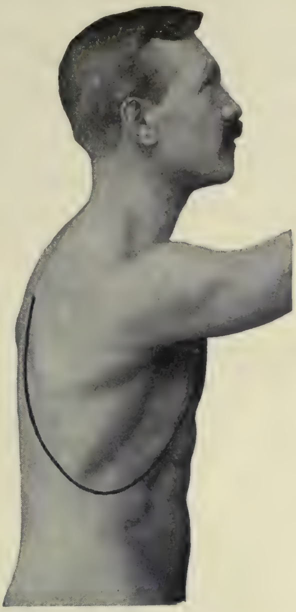

FIG. 248.—Thoracoplasty. Schede's incision, employed in large old-standing empyemas.

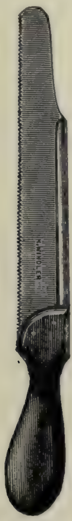

FIG. 249.—Large metacarpal saw.

4. *Excision of the Scapula.*

Total removal of the shoulder blade is performed mainly on account of sarcoma. To eradicate the disease it is necessary to thoroughly remove the periosteum and the neighbouring soft tissues; we shall describe the wider excision and not the subperiosteal method. Place the subject on the sound side and pull the arm forwards on the affected side. The operator stands facing the back. Take a sharp knife and divide the thick skin of the dorsum along the spine of the scapula, from the acromio-clavicular joint to the vertebral border. Add a linear incision at the inner border of the bone, carrying it downwards to the angle. This is Langenbeck's incision (Fig. 250). Insert sharp retractors into the wound and turn down a flap of skin and fat, thus exposing the fascia covering the muscles on the back of the scapula. A large number of the muscles inserted into the bone must now be separated or cut away, beginning with the posterior part of the deltoid (inserted into the spine). The muscles that run from the scapula to the posterior aspect of the humerus, the suprasinatus, infraspinatus and teres minor muscles, are exposed and divided; do the same to the teres major, which is inserted into the anterior side of the humerus. We thus obtain access to the shoulder joint; it should be opened from behind, the incision being made to correspond to the glenoid margin. Divide the ligaments connecting acromion and clavicle at the acromio-clavicular joint and pull the spine of the scapula strongly backwards. The humeral head should now be lifted still further from the articular cavity and drawn forwards. Divide the one remaining muscle connecting scapula with humerus; this is the stout subscapularis, which is inserted into the lesser tuberosity of the humerus. Retract up the upper edge of the wound once again and separate the trapezius from its insertion into the spine right along from the acromion to the base of the spine. This enables us to reach the insertions of the omo-hyoid, levator anguli scapulae and two rhomboid

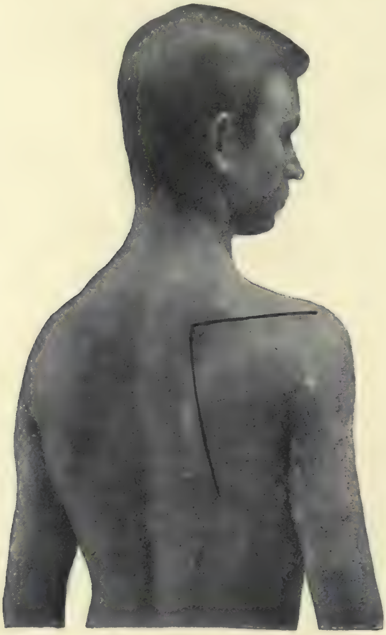

FIG. 250.—Incision for the excision of the scapula.

muscles, which are then to be divided near the inner border of the bone. Pull up the angle of the scapula and proceed to separate away the serratus magnus muscle at the vertebral border. The bone is now free to be raised in all directions; it is still attached, however, to the anterior part of the capsule of the shoulder joint and by the three muscles inserted into the coracoid process; these last (the coraco-brachialis, short head of the biceps and the pectoralis minor) are divided close to the coracoid process. This completes the extirpation of the scapula. This leaves the clavicle projecting outwards, and in order to provide favourable conditions for healing it is desirable to saw off the acromial end; our chief aim in the after treatment of the wound is to restore the muscles to their original points of insertion. We take the muscles that went to the coracoid process and suture them to the end of the clavicle; we then proceed to fix the humeral head in position; at this point the remains of the capsule come in very handy: we fasten it with stout sutures to the periosteum of the clavicle and to the remains of the deltoid muscles. We cover the back of the joint and close the wound by approximating and stitching up the remaining ends of muscle in a horizontal and a vertical line, which corresponds roughly to the skin incision. Perform drainage and suture the skin.

5. *Exposure of the Spinal Cord* (*Laminectomy*).

To reach the spinal cord we strike straight forward from the middle of the back, removing the spinous processes and the neural arches in the region we wish to expose. Fig. 251 shows a vertebra in transverse section: the darker portion indicates the part to be removed: the diagram illustrates how we can obtain ready access. Experience has taught us that temporary osteoplastic flaps of the neural arches are difficult to make and are really unnecessary in view of the fact that a series of spinous processes and neural arches can be removed without any resulting loss of stability to the vertebral column.[1]

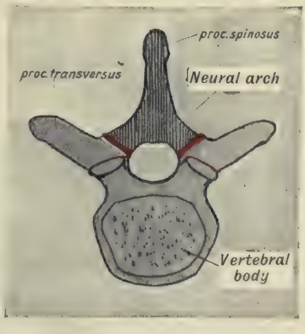

FIG. 251.—Diagram of a Vertebra. In laminectomy the spinous process and the neural arch are removed between the red lines.

The operation runs as follows: The subject lies prone, with a thick pillow under the chest to create kyphosis of the spine. With a strong bone-knife incise directly on to the spinous processes of the lower dorsal region and expose four or five of them. Retract the edges of the skin and expose the spinous processes and the posterior layer of the lumbar aponeurosis covering the erector spinae. Cut the aponeurosis from the bone and interspinous ligament on each side. Then exchange the knife for a broad straight chisel and apply it near the line of the processes;

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[1] The original method, to turn down several of the neural arches in one piece, is still employed. It is relatively a conservative operation.—TR.

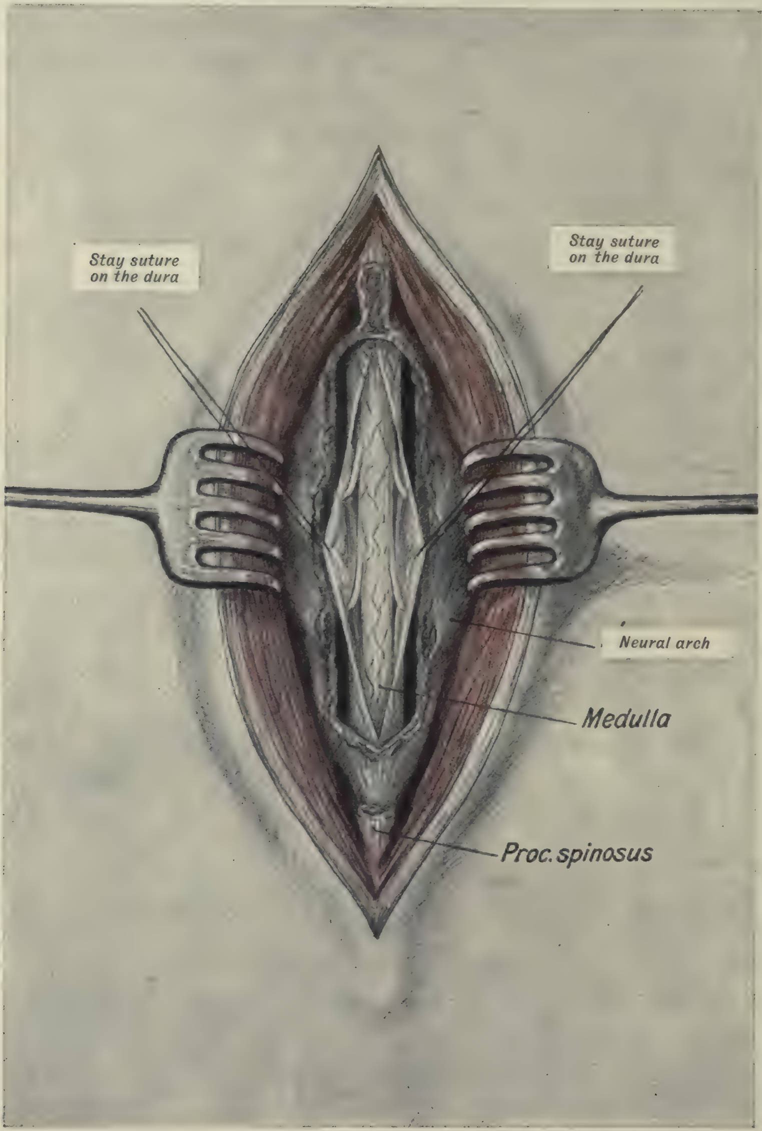

FIG. 252.—Exposure of the spinal cord (Laminectomy). After exposing the posterior aspect of the vertebral column we remove the spinous processes and neural arches of three vertebrae. The dura spinalis is slit open in the mid line.

lever up the long extensor muscles of the back as far as the root of the spinous processes and then raise them from the back of the neural arches, until you can feel the root of the transverse process with the chisel. This separation is done in the whole extent of the skin and fascial incision and should be repeated on the other side. The attendant hæmorrhage is considerable, and this is the only operation in which we are not always able to restrain it. Having thus separated off the muscles on both sides, insert large deep retractors, pull the muscles apart and survey the whole field of operation (the spinous process and the neural arches). The operator next takes a strong pair of gouge forceps (Luer's), seizes one of the exposed spinous processes and nips it away at its base. The interspinous ligaments were either divided previously, or an attendant cuts them now with a strong pair of scissors; the operator maintains his forceps on each detached spinous process and draws it firmly out. After three spinous processes have been removed in this way the neural arches are seen with the strong ligamenta subflava stretching between them. Then take a small Luer's forceps and bite away the neural arch piece by piece till we have made an opening the size of a sixpence; we are now able to palpate into the neural canal, and feel the epidural fat. The further exposure is easy. Using fine forceps we gradually bite away the whole of the posterior wall opposite two or three vertebrae and come in sight of the dura mater: it lies surrounded by fat, which is very rich in veins and not easy to strip away. The bone instruments must be employed in such a way that the cord does not receive the slightest pressure or injury. Operator and assistant now catch up the dura in two folds with fine toothed forceps: open the dura and the delicate arachnoid with a fine sharp knife in the mid line, and divide them upwards and downwards with guarded scissors. Fig. 252 illustrates the exposure of the cord and posterior sensory roots. Pass silk sutures through the dural flaps and draw them up and out. It is now possible to raise the posterior nerve roots with a fine blunt retractor, to rotate the cord carefully and to draw it to the side. The anterior roots now come into view.

As regards the treatment of the wound, we first close the linear cut in the dura with a fine continuous suture. Buried wire sutures are then passed deep through skin, fascia and erector spinae; at the end of the operation they should be tied over a roll of gauze. Then the lumbar aponeurosis and, lastly, the skin, should be accurately sutured.

6. *Pericardiotomy and the Exposure of the Heart.*

It may be necessary to make a wide opening into the pericardium in the case of suppurative pericarditis. The old intercostal incision has been abandoned, however, and nowadays we operate immediately to the left of the sternum and resect the cartilages of the fifth and sixth ribs. This typical operation should be practised on the subject.

In pericardiotomy and in free exposure of the heart we have to guard against a double danger—injury to the internal mammary artery on the one hand, and injury to the pleura on the other. One must recollect that the pericardium is normally in relation only to a small part of the anterior chest wall (cp. Fig. 253); this area lies in relation to the lower half of the body of the sternum. It is only at the sternocostal articulation of the sixth rib that this area projects a little to the left of the left sternal margin. The pericardium can therefore be reached directly by resecting the sixth cartilage. The rest of the pericardium is completely covered by the two plural sacs overlapping it from both sides, and an exact knowledge of the lines of anterior pleural reflection is essential in order to avoid them and displace them backwards in exposing the heart. Fig. 253 shows that the lines of reflection run parallel to each other as far as the fourth rib; the left pleural line then diverges outwards and follows the left border of the sternum down as far as the left sterno-costal junction of the sixth rib. The internal mammary artery runs vertically downwards behind the costal cartilages, about ½ in. out from the edge of the sternum (cp. Fig. 253). If injured in the living subject it gives rise to fierce bleeding, and if the incision is carried across it the vessel should be carefully exposed, doubly ligatured and divided.

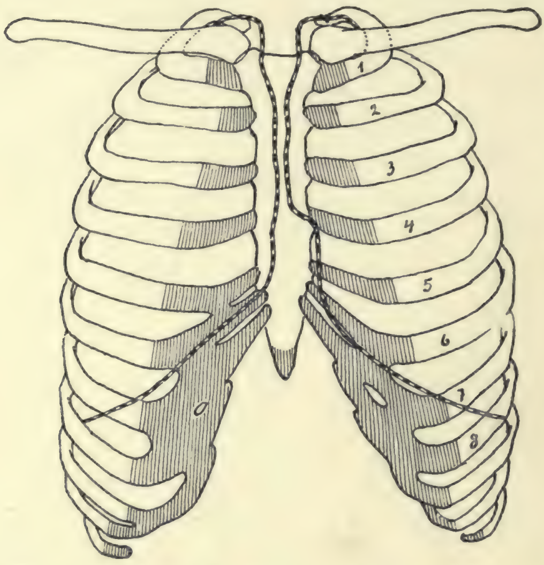

FIG. 253.—Diagram giving the lines of pleural reflection (the dotted lines).

The operation of pericardiotomy, according to Kocher, runs as follows: Count down the ribs till you come to the sixth, and carry a 4-in. incision (10 cm.) obliquely across its cartilage. The incision begins in the mid line of the body over the sternum (the lower oblique incision in Fig. 254), and divides skin, fat, pectoralis major, a part of the sheath and fibres of the rectus abdominis muscle and the perichondrium of the sixth costal cartilage. Do a careful subperiosteal resection of the sixth cartilage. Carefully deepen the oblique incision through the posterior perichondrium, and expose the triangularis sterni muscle: the internal mammary artery, with its venae comites, will be found lying on the muscle. Doubly ligature and divide the vessels, divide the triangularis sterni, and displace it and the pleural reflection outwards. This exposes the pericardium, which can then be opened between two forceps. If the opening be insufficient, the fifth and fourth costal cartilages can be divided close to the sternum (always preserving the central end of the internal mammary artery) and the pericardium incised vertically upwards.

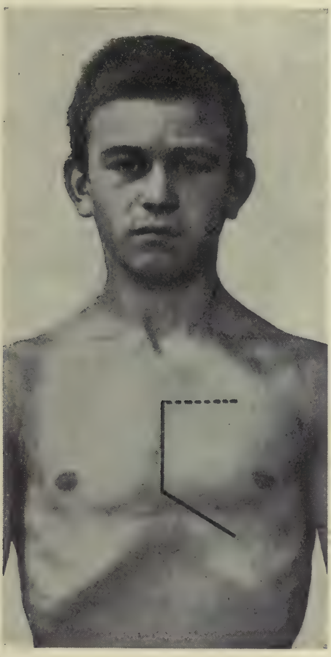

FIG. 254.—Kocher's incision for the exposure of the heart.

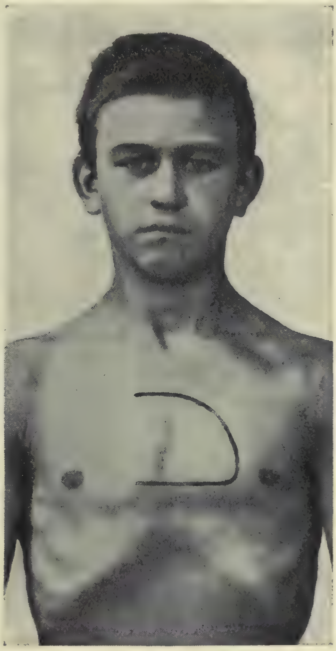

FIG. 255.—Flap incision for the exposure of the heart.

In describing how to make a still more thorough exposure of the heart, *e.g.* in order to suture up a wound in the cardiac wall, we adhere closely to Kocher's directions, as we have not had the opportunity of recapitulating the operation on the living subject. Various incisions are practised, but they all have the one object, to turn up an osteoplastic flap of skin, muscle and bone, and to gain access with as little injury to the pleura as possible. We attach particular value to the incisions shown in Figs. 254 and 255.

There are other methods, where a wide opening is made into the pleural cavity by turning inwards an even larger plastic flap of the chest wall, but they need not be discussed. The method given in Fig. 254 is strongly advocated by Kocher, and is excellent. A flap is formed with its base outwards. The primary incision resembles that done in pericardiotomy: it possesses, to our mind, the great advantage that it can be enlarged during the course of operation to meet the requirements of the case. We shall describe it immediately. Flaps can be formed with their

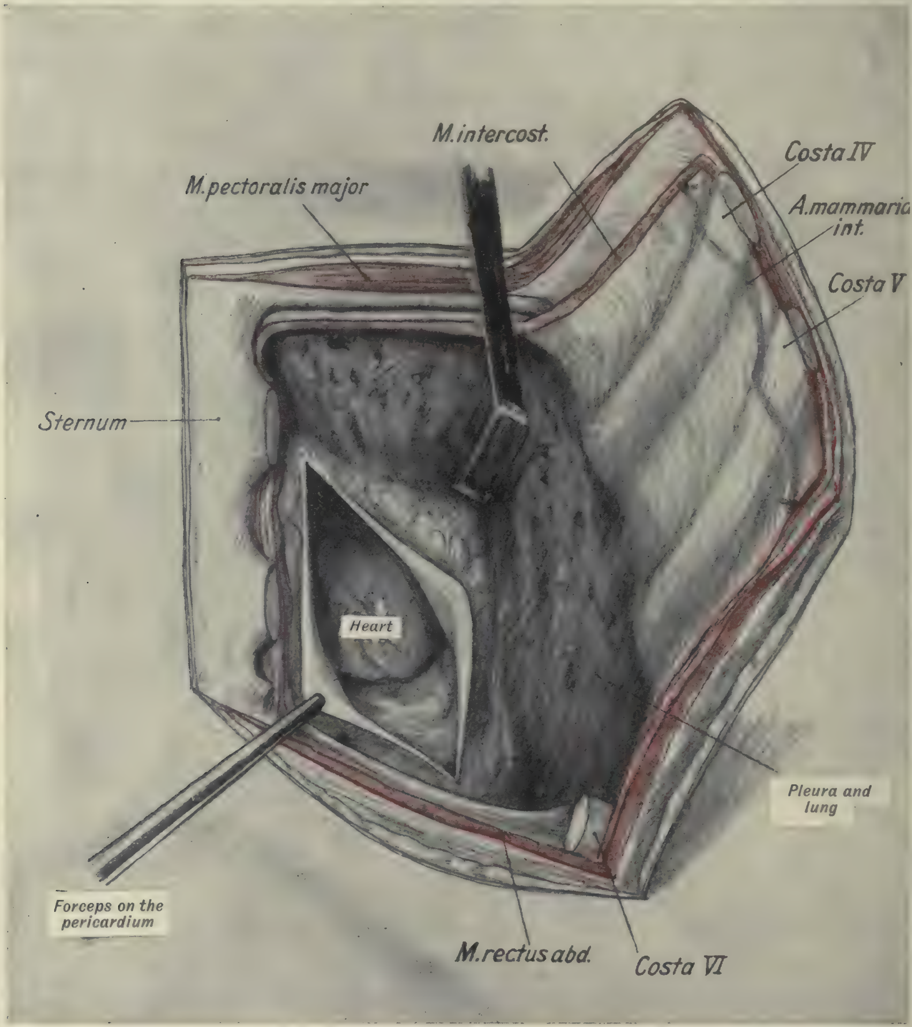

FIG. 256.—Exposure of the heart. In Kocher's incision a large flap of skin, muscle and cartilage is lifted and turned outwards, the pleura is retracted and the pericardium opened.

base at the right border of the sternum, but they necessitate a transverse resection of the sternum. They are therefore less conservative and it is more difficult to preserve the pleural sacs than when we follow the incision in Fig. 254, and aim at exposing the part of the pericardium uncovered by pleura.

According to Kocher's directions the operation runs as follows: Make a vertical incision down the middle of the sternum from the level of the third rib to the sixth; from here slant it obliquely outwards and downwards along the sixth costal cartilage and on to the sixth rib (Fig. 254). Detach the pectoralis muscle, divide some of the fibres of the rectus abdominis and resect the sixth costal cartilage as in pericardiotomy; doubly ligature and divide the internal mammary artery and veins at this point. Then divide the fifth and fourth costal cartilages close to the sternum and cut through the tendinous insertion of the triangularis sterni; in some cases the third is divided as well. A considerable part of the pericardium is now exposed, especially when the triangularis sterni and the left pleural fold are carefully displaced to the side and the fifth and fourth costal cartilages elevated. For a more complete exposure of the heart, the best way is to add a transverse incision as dotted in Fig. 254, at the level of the third rib (or it may be the second). Divide the pectoralis fibres and the intercostal muscles between the third and fourth ribs; and it is as well to ligature and divide the internal mammary artery and veins once more. The pleura is carefully pushed to the side, and we are now able to bend over the flap of skin, muscle and cartilage until the costal cartilages break away at the costo-chondral junctions; this hinge-flap affords us ready and extensive access to the heart. Displace the trianglaris sterni and the pleural fold to the left, and make an oblique incision into the pericardium. This stage of the operation is illustrated in Fig. 256. Should it be deemed desirable to extend the operation further to the right, we can gradually bite the sternum away with Luer's forceps or add a hinged osteoplastic flap. The exposure shown in Fig. 256 is usually quite sufficient: it will even allow the heart to be pulled forward. In many cases it is sheer waste of time to strive to preserve the pleura intact; more particularly is this the case when a stab or bullet-wound has hit both heart and left pleural cavity; there need be no hesitation either in opening the pleura if you have a pressure-regulating

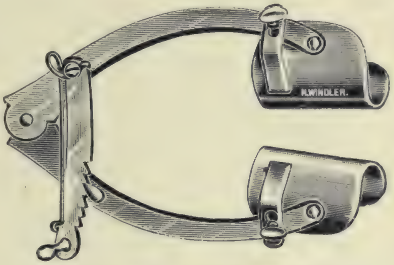

FIG. 257.—v. Mikulicz's rib-retractor.

apparatus at hand. These reflections led Wilms to reintroduce the old simple method of intercostal incision. The exposure can be carried out in the following way: Turn the patient half over to the right side. Make an incision in the anterior half of the fourth left intercostal space, and carry it through skin, musculature, pleura and pericardium, avoiding any injury to the pleura pulmonalis or the wall of the heart. Seize the pericardium with Mikulicz peritoneal forceps. Then introduce a large Mikulicz spanner (*v.* Fig. 257) between the ribs and force open the wound as far as possible.

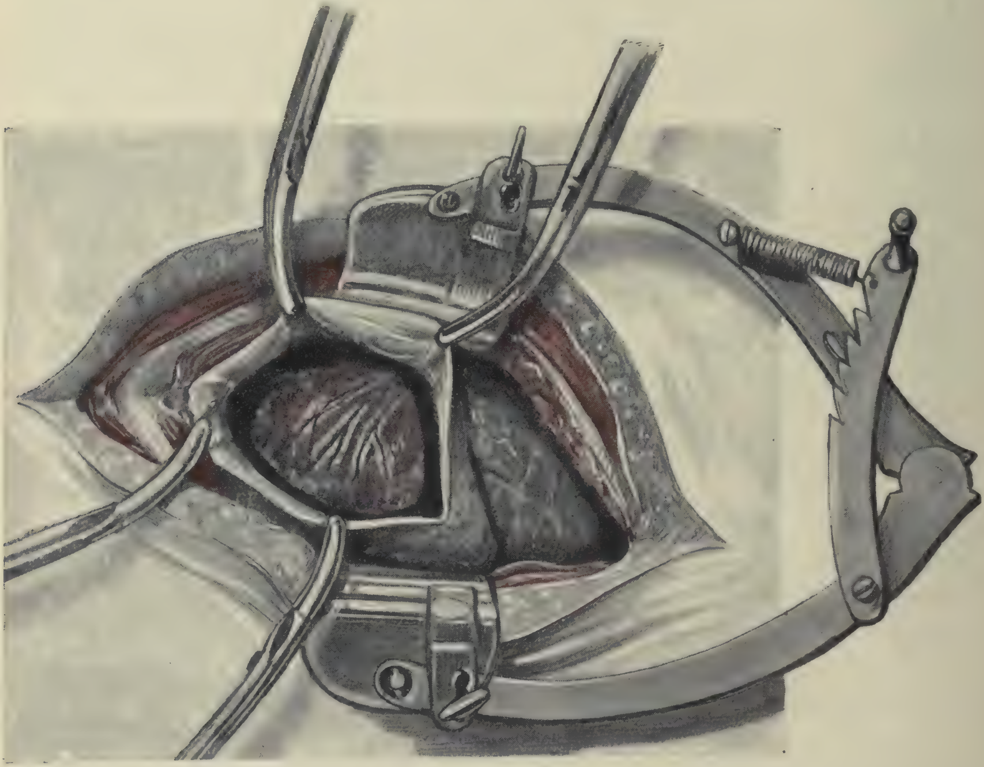

FIG. 258.—Exposure of the heart by means of the intercostal incision.

The majority of operations on the heart can be successfully carried out through this opening (*v.* Fig. 258). Remove the rib-spanner. In closing the wound suture the pericardium first. Then firmly coapt the displaced ribs by introducing a few deep sutures round the adjacent ribs and tying them tight. Then suture up the muscles and the skin. Sauerbach has been the chief pioneer in the technique of thoracic surgery.

Wounds of the heart are closed by tying a few silk sutures, drawing them tight during systole. Rehn was the first to suture the heart.

7. *The Radical Cure of Hernia.*

The oblique is the most frequent of all hernias. A finger-like process of peritoneum ("the sac") passes obliquely through the abdominal wall and travels alongside the spermatic cord; it may contain omentum or bowel. Radical cure aims at the extirpation of the hernial sac and depends on an exact closure of the enlarged inguinal canal. In Bier's clinic we employ Bassini's method almost exclusively. Of course we shall find neither rupture nor hernial sac in the dead subject; it is still possible, however, to make a success of the operation, for the essential point in the whole procedure is to close up the breach in the inguinal canal.

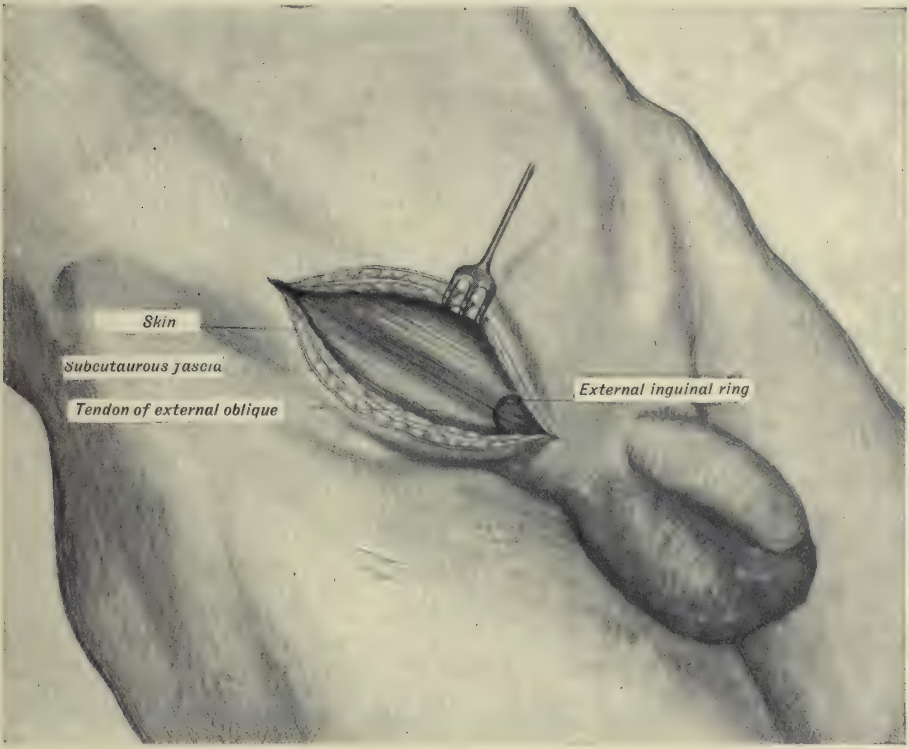

FIG. 259.—Bassini's radical cure of inguinal hernia. I. Stage. Skin incision and exposure ot the aponeurosis of the external oblique.

(*a*) *Bassini's radical cure.*

Place the subject on the back and palpate the external inguinal ring with the tip of the forefinger. This is an opening in the aponeurosis of the external oblique muscle through which the spermatic cord descends into the scrotum ; we can palpate it either directly through the abdominal wall or still better, by invaginating the skin of the scrotum and pressing the finger up under the subcutaneous tissue along the course of the cord. Next make an oblique incision as shown in Fig. 259 ; it lies entirely above Poupart's ligament but is not quite parallel to it, being rather more vertical. It measures about 4 in. (10 cm.) in length and ends a little below the external ring, which it exposes. The end of the incision should not come too near the root of the penis and should not be prolonged on to the wrinkled skin of the scrotum. It divides skin, fat and subcutaneous tissue, and exposes the smooth tendinous fibres of the external oblique in the direction of the symphysis.

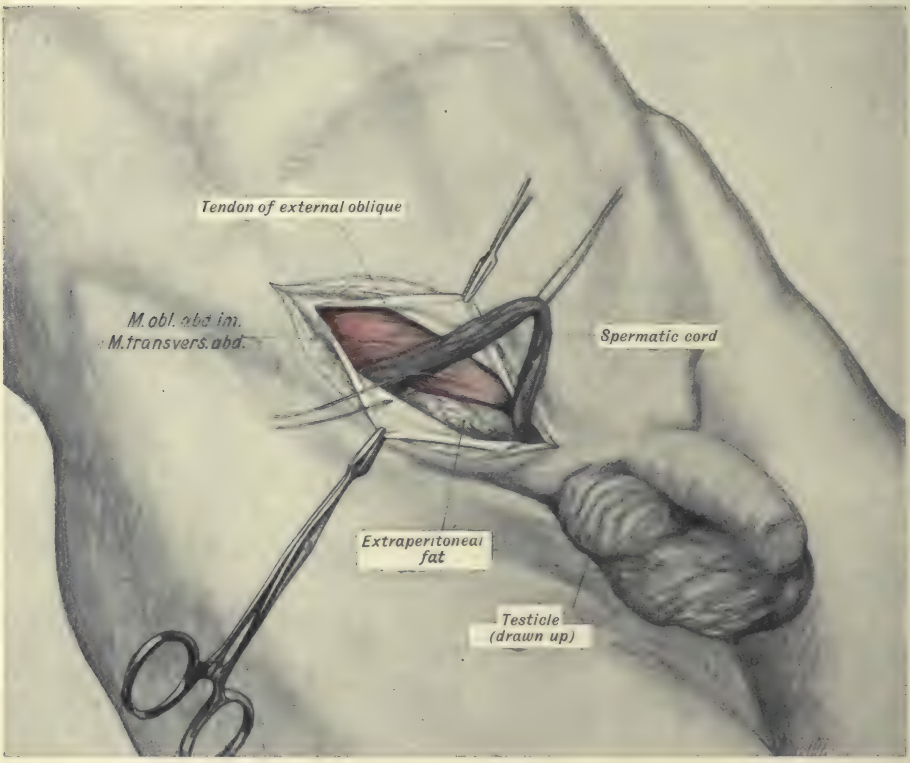

FIG. 260.—Bassini's radical cure of inguinal hernia. II. Stage. The aponeurosis of the external oblique is divided and its edges retracted, the spermatic cord lifted and the internal ring exposed. The first deep suture is introduced, but not yet tied.

In the second stage of the operation we divide the tendon of the external oblique along the dotted line in Fig. 259, incising as far as the external ring ; we lift up the muscle in the flaps, turn them over like the pages of a book and retain them in this position by means of Pean's clamps. We now raise the cord out of its bed and hold it up by slinging a thread round it. This stage is shown in Fig. 260: The tendon of the external oblique has been folded over and the white border represents the shining posterior aspect of Poupart's ligament: this tendinous fold is of importance for the later suturing. Under the upper flap of the external oblique there lies the conjoined tendon of the internal oblique and transversalis muscles. In the depth of the wound we see a large opening, backed up by extraperitoneal fat; this is the enlarged internal ring, the closure of which we must regard as the most important point in Bassini's operation. In pulling up the spermatic cord we also dislocate the testicle upwards in the scrotum. We next isolate the sac from the elements of the cord and treat it in the usual way. In general terms, we push the contents of the sac back into the abdomen, provided they are not adherent; if adhesions are present, we open the sac, free the contents and either replace them in the abdomen or resect

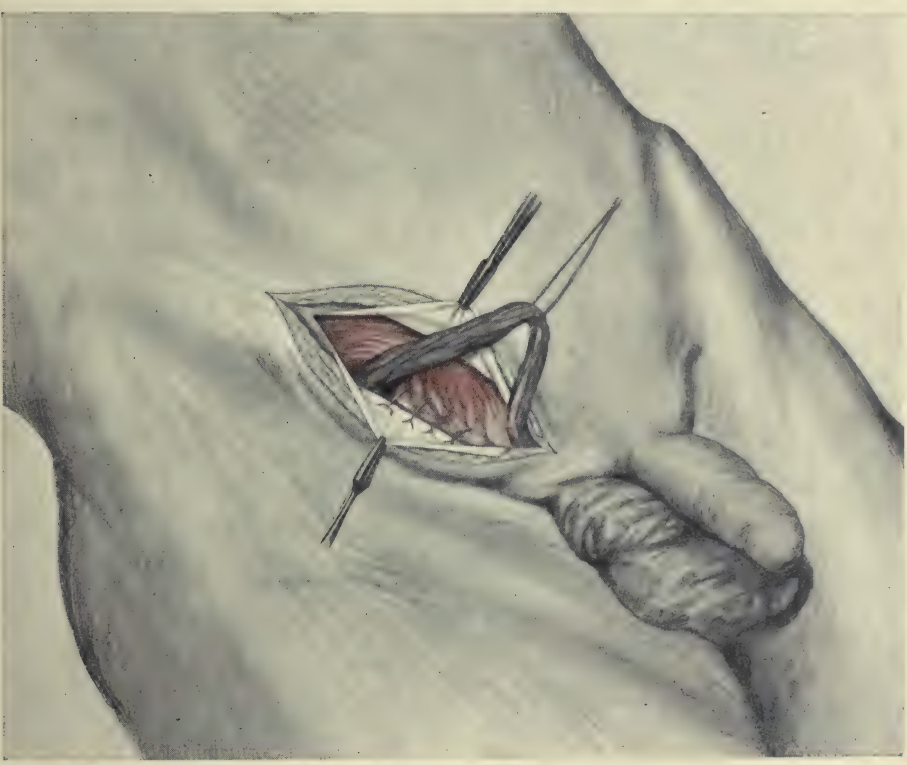

FIG. 261.—Bassini's radical cure of inguinal hernia. III. Stage. The deep sutures are introduced and tied.

some of the omentum. We then stitch up the hernial sac as far as possible and excise it; its stump disappears in the upper angle of the wound.[1]

We now proceed to the third stage of Bassini's operation—the suturing up of the tissues; the first suture is shown still untied in Fig. 260. The operator passes a stout suture through the edges of the two deep abdominal muscles (conjoined tendon) and then through the edge of the tendinous fold of Poupart's ligament described above; this stitch should be made carefully so as not to injure the underlying femoral vessels. Three to five of these sutures are introduced according to the size of the hernial opening: they are left untied at first. The lowest suture should ensure an absolute closure at the lowest angle of the wound; it therefore passes deep down on to the periosteum of the os pubis which it catches up near the pubic spine. When all the sutures are in place, tie them tight one after the other and cut them short. The spermatic cord is held well upwards during this whole procedure. The suture is shown completed in Fig. 261. Feel with the finger tip and test whether there is not any opening still present, either above or below, that would favour the occurrence of a fresh rupture. The new opening in the upper angle of the wound for the cord to pass through must not be larger than is necessary for free circulation to the testicle; we should never be able to introduce the tip of the little finger in addition to the cord. The cord is now replaced and the thread holding it removed; it is laid on Bassini's suture line; the testicle falls back into the depth of the scrotum, and we take off the Pean's forceps and fold back the aponeurosis of the external oblique. As shown in Fig. 262, the edges of the longitudinally split aponeurosis are carefully coapted with the finest sutures, to form a roof for the cord. On the completion of this stitch we are presented with a picture that reminds us of Fig. 259. The typical operation finishes with an accurate suture of the skin and superficial fascia.

There are a number of more or less useful modifications to the above procedure, but none of them equals Bassini's operation in importance. We shall therefore not describe them.

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[1] In nearly all operations for hernia the results are good. But it is not ideal to leave a small funnel of peritoneum behind, for it renders the patient liable to another rupture. Macewen advised therefore that the empty sac should be utilized to form an organic intra-abdominal pad at the internal abdominal ring. Pass a stout chromicised catgut stitch through the distal end of the sac, and having tied it pass it first from before backwards and then from behind forwards through the sac, so that when pulled upon it may crumple up the sac into a frill. The loose end of the suture is then threaded on a large blunt hernia needle—blunt, so as not to injure the deep epigastric artery. Pass the needle up the canal and force it through the muscles of the abdominal wall above and to the inside of the internal ring. Catch the end of the suture and withdraw the hernia needle. If the suture is now pulled upon the sac will fold up and form a firm pad lying between the peritoneum and the abdominal muscles at the inner side of the internal ring. The long suture can be used for stitching up the aponeurosis of the external oblique, or for narrowing the external ring if the aponeurosis has been preserved intact.—Tr.

(*b*) *Kocher's operation for inguinal hernia.*

Unfortunately this is an operation that cannot be practised often on the subject, for it presupposes a hernial sac. Kocher exposes the aponeurosis of the external oblique as in the first stage of Bassini's operation, but does not divide it. He now isolates the hernial sac from the spermatic cord, empties it and invaginates the empty hernial sac upwards with a pair of long dressing forceps just as one would flipe the finger of a glove ; he pushes up the hernial sac with the forceps and carries the end of it through a small slit in the aponeurosis of the external oblique and out at the upper angle of the wound. The hernial sac is drawn tight into the small slit in the parietal peritoneum, the fascia stitched to it firmly and the slit itself securely closed round it; the projecting part of the sac is then cut off. After treating the hernial sac in this way the external oblique aponeurosis is

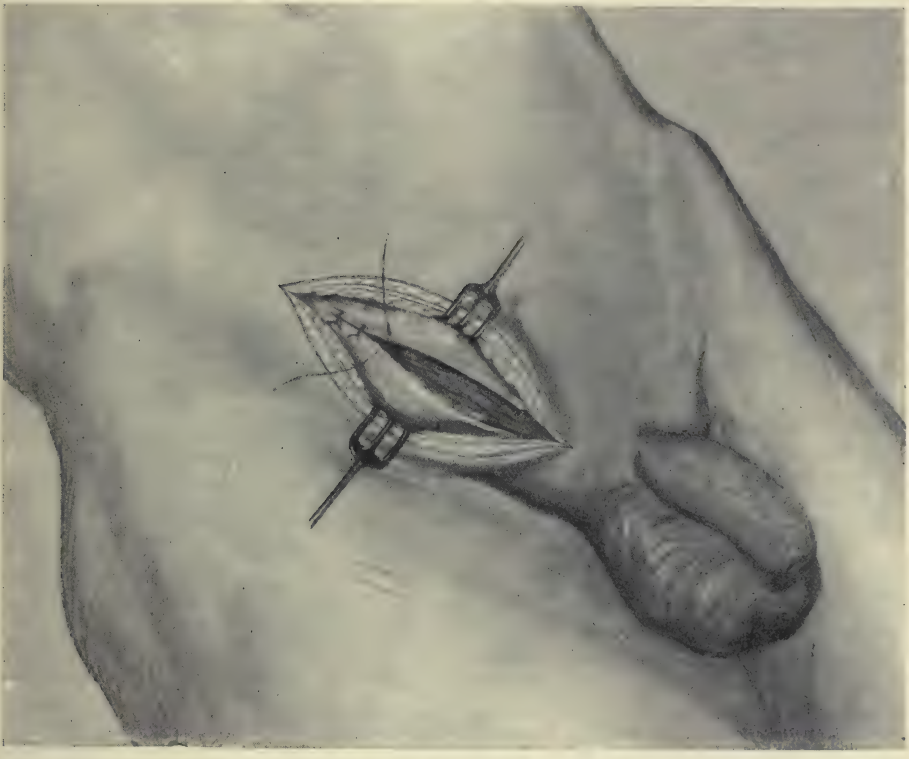

FIG. 262.—Bassini's radical cure of inguinal hernia. IV. Stage. After the deep suture the spermatic cord is replaced ; we then proceed to stitch the aponeurosis of the external oblique.

doubled over the cord in two large parallel folds and the whole canal sutured up right down to the inferior angle of the wound. If it is found impossible to invaginate the sac it may still be possible to implant it into the parietal abdominal wall. Complete the operation by suturing the canal and stitching the skin.

8. *Radical Cure of Femoral Hernia.*

This operation is also of practical importance and all the essential points can be studied on the subject, even though there be no hernial sac. While inguinal hernia appears above Poupart's ligament, femoral hernia appears below it, and always at a characteristic anatomical site, at the inner side of the femoral vein. The position of the rupture will be understood from the accompanying diagrammatic section (Fig. 263), which represents the space between Poupart's ligament and the bony pelvis.

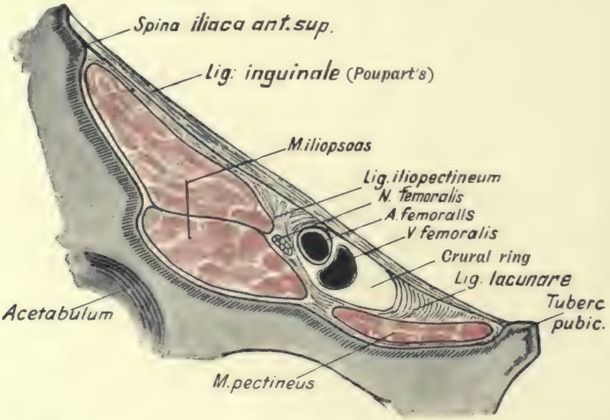

FIG. 263.—Diagrammatic section through the crural ring.

Poupart's ligament is seen spanning the curved wall of the pelvis like a tendon ; it runs from the anterior superior spine to the spine of the pubis. The ilio-pectineal fascia divides the large opening into a muscular and a vascular compartment. The former is occupied by the ilio-psoas muscle and contains also the anterior crural nerve ; the latter is occupied in greater part by the large femoral vessels. The anatomy of the vascular compartment is important enough to merit a more exact description. The femoral artery is always found to the outside and the femoral vein to the inside ; on the inside of the vein again we find the crural ring (Annulus femoralis) : this is normally closed by the septum crurale, a weak process of the fascia transversalis ; it is through this ring that femoral hernia comes. Its boundaries are as follows :—the femoral vein to the outside, Poupart's ligament above, Gimbernat's ligament to the inside, and the pectineal fascia and pectineus muscle below. The pectineus muscle lies on the periosteum of the horizontal ramus of the pubic bone.

Femoral hernia consists in a projection of the peritoneum through the septum crurale. The crural canal is occupied at this point by the lymph gland (of Rosenmüller) and some loose fatty tissue; the hernia descends along the inside of the femoral vein, pushes the contents of the canal before it and forces its way downwards under Poupart's ligament and through the cribriform fascia of the saphenous opening.

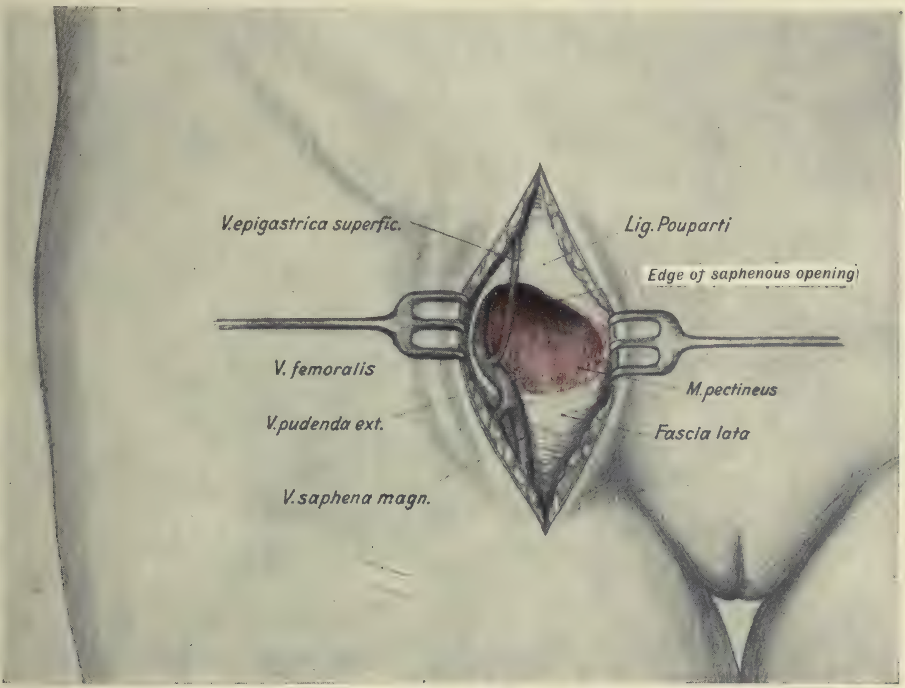

FIG. 264.—Radical cure of femoral hernia. I. Stage. Exposure of the temoral opening.

The operation is practised as follows: Commence the incision at the junction of the middle and inner thirds of Poupart's ligament and carry it about 2½ in. (6 cm.) downwards through the skin and superficial fascia. Expose the cribriform fascia, the inner edge of the femoral ring and its attachment to Poupart's ligament, and the ligament itself. The internal saphenous vein and its branches run in the subcutaneous tissue and dip down over the lower edge of the femoral ring to join the vein: the superficial epigastric vein ascends vertically upwards; the superficial external pudic vein passes transversely inwards. Introduce the finger and palpate the crural canal; in cases where no femoral hernia is present, the opening is very narrow and seldom admits the little finger: it is filled with fat and lymphatics. Gimbernat's ligament can be palpated on the inside, the pectineal fascia below, Poupart's ligament above, and to the outside an idea can be gained of the position of the femoral vein but without isolating it from its sheath. Remove the fat and the lymph nodules and expose the crural ring. The way to penetrate into the abdomen in the normal subject is to thrust a blunt instrument through the septum crurale, to the back of which the peritoneum is directly applied. These anatomical relationships are shown in Fig. 264.

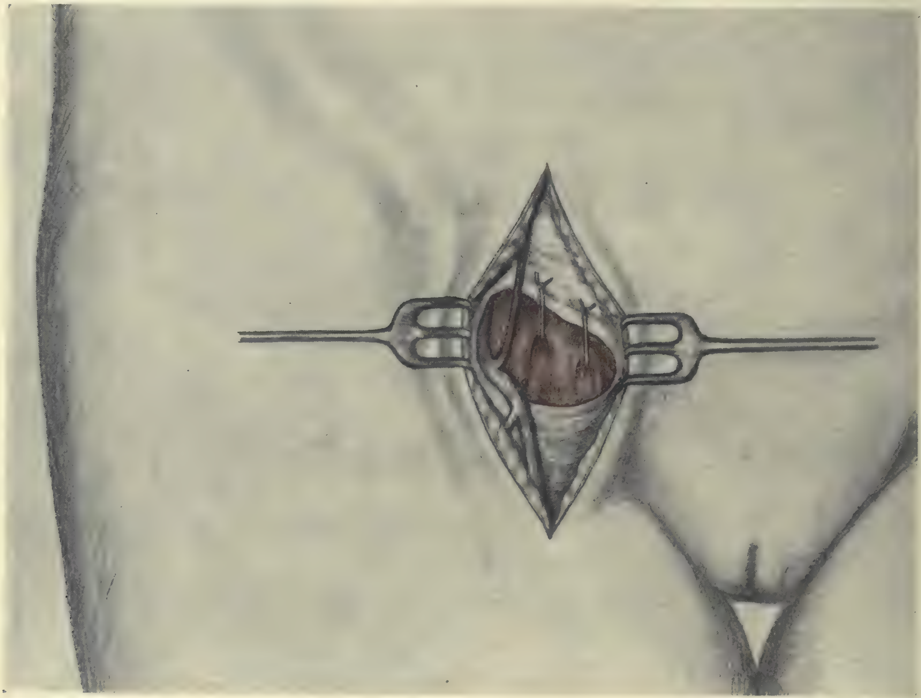

FIG. 265.—Radical cure of the femoral hernia. II. Stage. Suture of the femoral opening.

Let us now consider the simplest and most effectual method for closing the crural opening in the majority of femoral ruptures: we refer to the suture of Poupart's ligament to the pectineal fascia, pectineus muscle and periosteum of the horizontal pubic ramus. One to three strong sutures have to be inserted according to the size of the opening: a short strong curved needle is employed. The description must be closely followed, for you are liable to puncture the vein or bring about a stenosis by introducing the lateral suture too near it. Fig. 265 shows how the sutures should be inserted. The first suture is introduced close beside Gimbernat's ligament; pass the needle through the edge of Poupart's ligament, then carry it vertically downwards into the pectineal fascia and muscle till the point of the needle rests on the horizontal ramus, then carry it in a short curve downwards and outwards. A second suture should be introduced a little further out before the first one is tied; it is carried vertically exactly in the same way. Then tie the two sutures, thus nailing Poupart's ligament to the pectineus muscle at the place where it bridges over the crural ring. The only way of finding out whether your closure is sufficient is to palpate with the finger and feel if the crural canal is tightly shut. Stitch up the skin. (A vascular anomaly, the corona mortis, is often mentioned, but is of no practical importance. The obturator artery sometimes springs not from the internal iliac, but from the deep epigastric artery, and crosses the neck of the femoral sac; it must be ligatured and divided at this point in the exposure of the femoral opening.[1])

9. *Extirpation of the Rectum.*

There are numerous operations on the rectum and anus, but for practice on the dead subject we describe the most radical and important of them all, the operation for cancer of the rectum. This operation must never be performed on the living subject except after the most careful internal examination. We must convince ourselves as to whether we are dealing with an operable carcinoma, we must discover the extent of the disease and especially the relations of the tumour to the neighbouring organs on which it has encroached. If the tumour is operable we have to decide as to whether the sphincter ani is to be sacrificed or not. Removal of the rectum and anus is termed Amputatio recti, an excision in continuity higher up with retention of the anal portion is termed Resectio recti.

The position of the rectum will be understood from Fig. 266. Notice that the terminal part of the great intestine lies completely extraperitoneal; the pelvic colon joins it from above. The latter is clothed with peritoneum in front and rests on the curve of the sacrum behind; as it is traced upwards the colon becomes quite free and is completely coated with serous peritoneum except at the attachment of the mesentery (the pelvic mesocolon). As shown in the diagram the peritoneum on leaving the upper surface of the bladder does not reach down to the upper border of the prostate but turns backwards and envelopes the anterior surface of the rectum. The prostate rests against the anterior wall of the rectum—the prostate itself, and the structures that adhere to its posterior surface, namely the seminal vesicles, the ureters and the vasa deferentia, may all be implicated in disease of the rectum and it is often a difficult matter to free them; the disease may even run downwards and involve the membranous urethra. Posteriorly the rectum lies in fairly close relationship to the sacrum and coccyx; it is surrounded by a layer of fatty areolar tissue and the rectal fascia; its terminal portion is clothed by the levator ani muscles as well. In the extirpation of the rectum all the neighbouring organs must be preserved as far as possible. In women the conditions are somewhat different, for the uterus is intraperitoneal and lies between the rectum and the bladder; we therefore designate the space that lies in front of the rectum and is bounded by the fold of the peritoneum as the recto-uterine pouch (pouch of Douglas). The lower part of the rectum abuts on the posterior wall of the vagina.

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[1] In dealing with a femoral sac it should be opened and its contents reduced. There are various ways of treating the sac; two simple methods are: (1) To cut away the terminal portion and stitch up the remainder.

(2) To free the sac and some of the parietal peritoneum and to convert it into an intra-abdominal pad (on the lines of Macewen's method).—Tr.

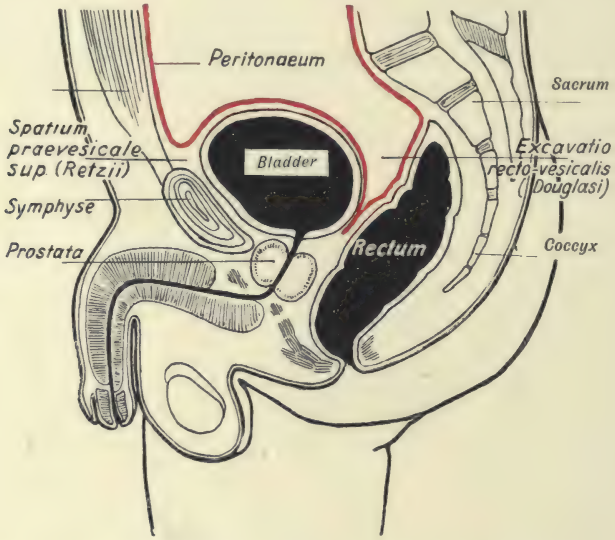

Peritonaeum
Sacrum
Spatium praevesicale sup. (Retzii)
Bladder
Excavatio recto-vesicalis (Douglasi)
Symphyse
Prostata
Rectum
Coccyx

FIG. 266.—Median sagittal section through the male pelvis. Peritoneum in red.

In rectal carcinoma we never do a partial excision of the wall, but always perform a circular excision two finger-breadths above and below the lesion. Kocher's dorsal operation affords a free exposure and is the method for choice, a linear incision followed by excision of the coccyx. In Kraske's method, not merely the coccyx, but also the lower end of the sacrum is removed; but this and osteoplastic methods in general have been gradually abandoned, for we find that the coccyx may be removed without serious consequences and that this is almost always sufficient. We do not propose to describe the perineal, vaginal and abdomino-sacral methods. The question of when to establish an artificial anus will also not be raised in this book; it belongs rather to works on clinical surgery.

(*a*) *Amputatio recti.*

The aim of this operation is indicated in Fig. 267. Almost the entire extraperitoneal rectum is removed together with the sphincter and anus; the pouch of Douglas is not opened. The resected end is pulled well down and stitched into the skin below (or lateral to) the coccyx, to form a so-called sacral anus. A large wound cavity is left between the rectum on the one side and the prostate, bladder and ureters on the other side; it is to be packed and left open.

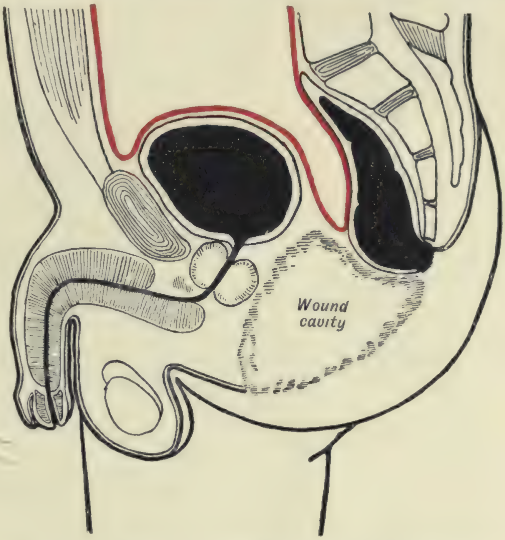


FIG. 267.—Diagram of the male pelvis after Amputatio recti and the establishment of a sacral anus.

The operation runs as follows: The subject is placed at the edge of the table and lies on the right side or even semi-prone, with the hips and the knees flexed. The operator stands facing the sacrum. Make a circular incision round the anus to correspond roughly to the size of a half-crown piece; stitch up the anal orifice with a stout silk suture. The ends of the suture are left long for purposes of traction. Incise backwards in the mid line from the ring incision to the tip of the coccyx, then slant the knife to the left along the edge of the coccyx and sacrum and carry it obliquely upwards as far as the great sciatic notch. The incision divides the thick skin, the dense fat and the solid fascia that covers the bones and ligaments; it divides the ligaments arising from the side of the coccyx and exposes the left border of the coccyx in its whole extent; it also divides the lowest fibres of the gluteus maximus and the great and small sacro-sciatic ligaments at their attachments to the sacrum; the ligaments come into view after the muscle is divided. After thorough division of the various fasciae and ligaments introduce the finger into the loose areolar tissue and palpate the ischio-rectal fossa. Open up the wound with large retractors on each side and with long sweeps of the knife on to the bone make a thorough exposure of the coccyx, cutting away the ligaments attached to its tip and right border. Free the anterior surface of the bone by blunt dissection.

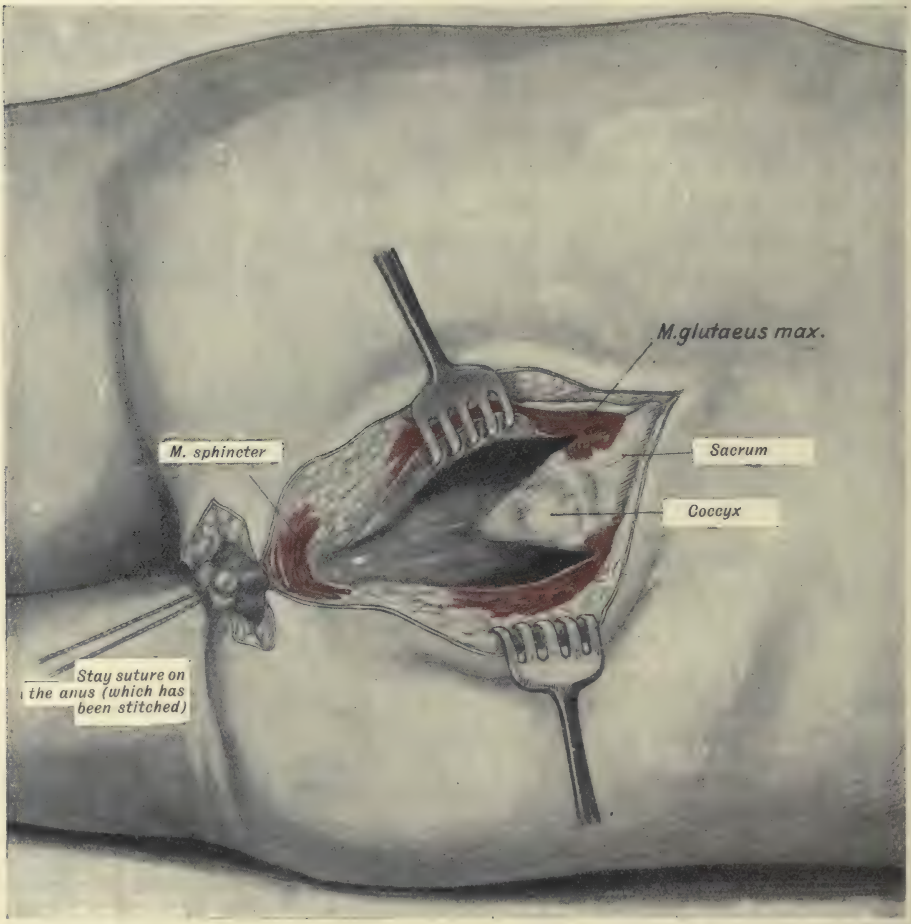


FIG. 268.—Amputatio recti. I. Stage. The anus is stitched up. The incision encircles the anus and exposes the posterior aspect of the rectum: the coccyx is freed on each side.

This stage of the operation is illustrated in Fig. 268. Next locate the sacro-coccygeal connection by waggling the coccyx and chisel transversely across at this point; the bone can now be freed from its synchondrosis with the help of the knife and completely extirpated. A broad fascia now comes into view, lying between us and the rectum; this fascia covers the levator ani muscle on each side; it sweeps down in the middle line and blends more or less firmly with the rectum. It is not at all easy to free the rectum from its connections and deliver it into the wound without opening this levator ani fascia; we have first to divide it in the mid line, where there is an entire absence of muscle fibres; an alternative method (Voelcker's) is not to divide the fascia in the mid line (where it blends with the rectum), but to divide the levator sheet in its muscular portion by two linear incisions a finger's breadth to right and left of the mid line and then make a transverse cut in the fascia of the levator ani so as to connect them. Through this opening it is easy to isolate the rectum

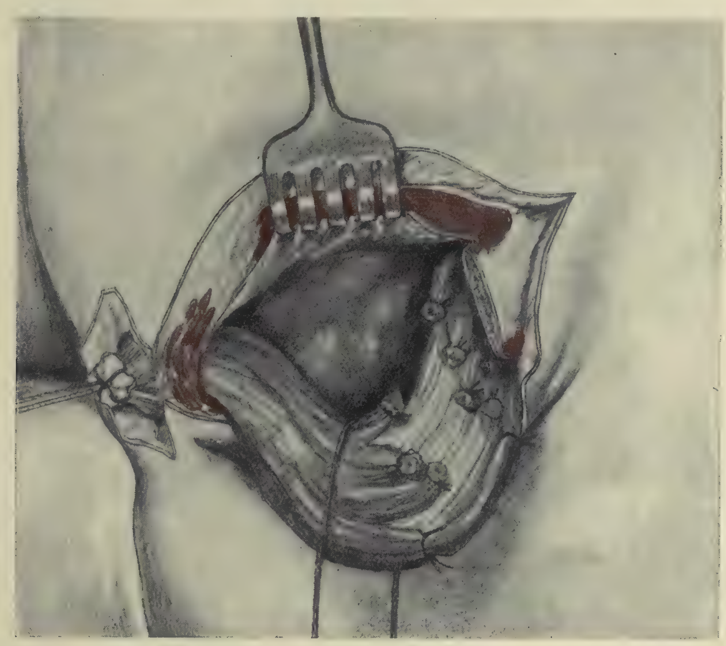


FIG. 269.—Amputatio recti. II. Stage. The coccyx is removed, the rectum completely freed, the haemorrhoidal vessels ligatured and divided.

from its loose fatty envelope; it is still surrounded however by the fascia recti propria (a part of the visceral layer of the pelvic fascia), and this must be divided before we reach the rectum itself; the fascia propria envelopes not merely the rectum, but the prostate and neck of the bladder as well, and in the female the cervix uteri. This description is based on Voelcker's work; he advises the linear division of this fascia propria on each side. The surgeon can then grasp the rectum itself and pull it out till he feels the prostate in front. The division of the fascia propria and the seizure and isolation of the rectum from the structures that lie in front of it (the prostate, seminal vesicles, ureters and urethra; the uterus and vagina in the female) should be carried out with care and deliberation and without injury to the neighbouring structures ; and above all, do not on any account open into the rectum, for the aseptic character of the operation must be maintained as long as possible. The procedure is materially simplified by the introduction of a heavy metal catheter into the urethra ; it can easily be felt in the wound and is of use when the intestine is being pulled downwards by means of the anal sutures. This isolation of the rectal ampulla should always be practised on the dead subject, for it is impossible to learn it from books or illustrations. Fig. 269 illustrates how the part of the rectum containing the tumour is drawn out with a stout suture and mobilized and shows the appearance presented by the prostate in the background. Following our plan of operation, *i.e.* Amputatio recti, we now proceed to excise the anal canal ; retract the skin on both sides and divide the fibres of the levator ani muscle and the pelvic fascia with knife or scissors, leaving the sphincter muscle attached to the rectum ; this separation must be done with the knife and not as in freeing the ampulla ; it occasions lively

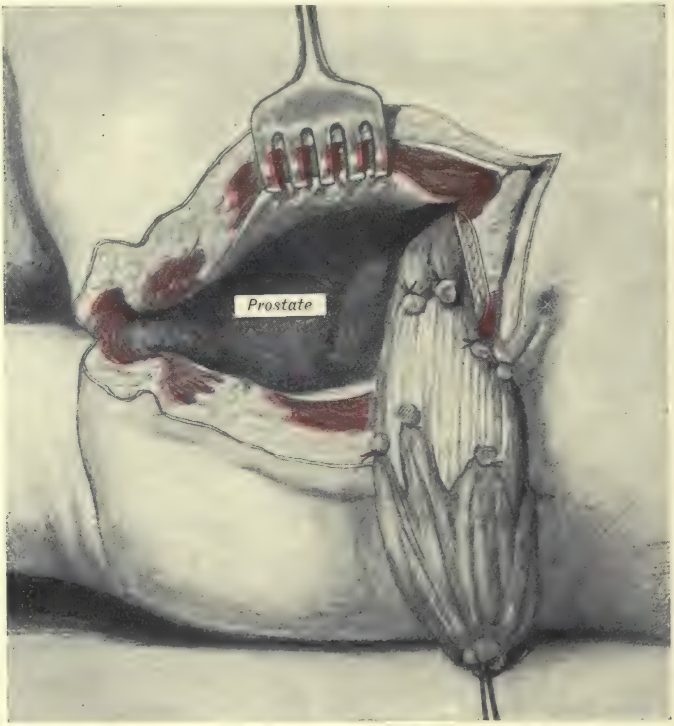


FIG. 270.—Amputatio recti. III. Stage. The anal canal is completely excised and hangs down with the rectum. The bladder and prostate are seen in the background.

bleeding in the living subject. The connections between the urethra and the rectum are particularly firm at the so-called perineal raphe. The rectum should be still intact at the end of the separation process and is free to be drawn out; we must gradually separate the bowel in an upward direction till it can be pulled out of the wound for a distance of two finger-breadths above the level of the carcinoma. Take an aneurism needle, pass a pair of sutures round the rectum and divide it; compare Fig. 270 for this stage of the operation. In low-seated carcinomas we are often able to avoid opening into the pouch of Douglas; this point will be referred to again in describing Resectio recti. Fig. 270 also shows how the urethra, prostate and allied structures are exposed in front after the separation of the rectum.

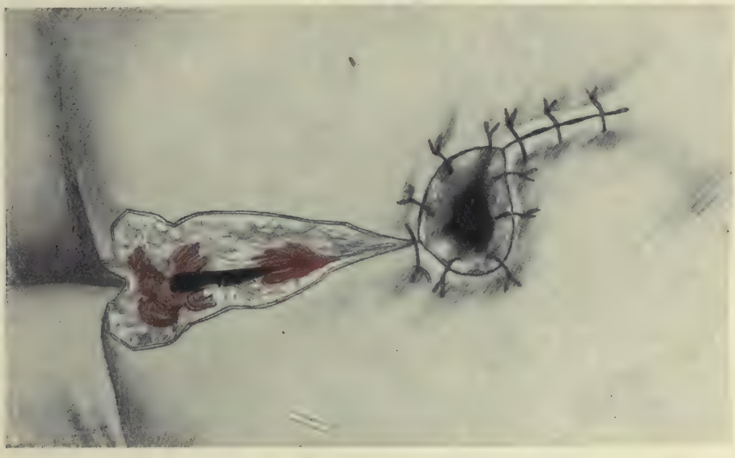


FIG. 271.—Amputatio recti. IV. Stage. The rectum is excised, and its end stitched to form a sacral anus. The lower cavity of the wound (cp. Fig. 267) is left completely open.

As the sphincter muscle has also been excised there is no use in drawing down the rectum to the position of the former anus and stitching it there; to avoid tension we would be obliged to make a quite unnecessary separation and might even endanger the circulation to the part. We therefore make a so-called sacral anus below the end of the sacrum or immediately to the left of it, and without opening into it attach the rectum to the dense subcutaneous fascia with six to eight pararectal sutures. We then pack the large wound cavity loosely with gauze, for we wish to leave it open. Divide the rectum transversely $\frac{3}{4}$ in. (2 cm.) from the edge of the skin and remove the diseased part. The hæmorrhage must be stopped in the living subject. Complete the operation by stitching up the mucous membrane of the rectum to the superficial skin with six to eight interrupted sutures, leaving large gaps between them (*v.* Fig. 271). The terminal stage of the operation is illustrated in Fig. 267.

(*b*) *Resectio recti.*

The aim of this operation is represented diagrammatically in Fig. 272. The anal canal is retained and a large part of the rectum is resected above it; the pouch of Douglas is opened and reclosed, after a large part of the pelvic colon has been drawn down and made to project into the natural anal orifice; the manner of fixation will be described later. The wound cavity is large and should be packed and left open; it lies behind the rectum and between it and the end of the sacrum.

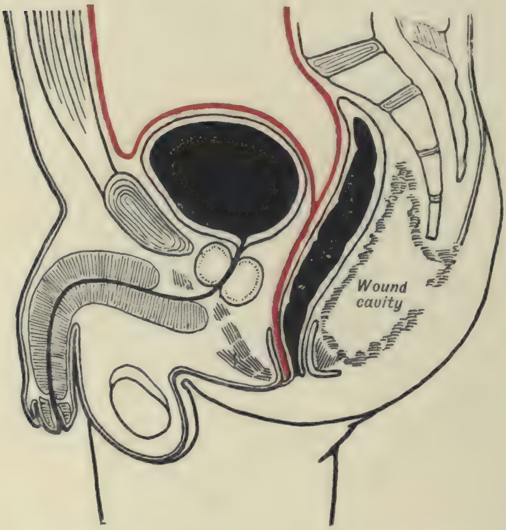


FIG. 272.—Diagram of the male pelvis after Resectio recti with opening of the abdominal cavity and suture of the gut (after Hochenegg).

It is our desire to maintain the aseptic character of the operation as far as possible; it runs as follows: The subject should lie exactly as in Amputatio recti. No initial circular incision is made round the anus, but we stitch it up absolutely tight in order to prevent escape of the contents. Commence the incision in the mid line between the anus and the tip of the coccyx and carry it vertically upwards; divert it to the left as before and divide the same muscles and ligaments; the coccyx is isolated and removed as in the amputatio, and this will usually be found sufficient; the aponeurosis of the levator ani and the fascia recti propria are then to be divided as in amputatio recti. If it now becomes evident on palpation that the rectal tumour extends very high, a portion of the end of the sacrum should be gouged away with Luer's forceps as far as appears necessary; but we must not go any higher than the third sacral foramen, for fear of endangering the innervation of the bladder. The rectal ampulla is now separated all round up to the level of the prostate; the position of the urethra is ascertained by means of a metal catheter. In these cases the disease is situated at a higher part of the rectum, and we next proceed gradually to free the gut. We make frequent use of the aneurism needle, doubly ligaturing and dividing the pararectal vessels as soon as they are met; drawing the rectum downwards as we go, we gradually win our way upwards and succeed in making a complete exposure all round the bowel. Snipping carefully with the scissors we reach the fold of Douglas a little above the prostate on the anterior aspect of the bowel; we open it and enter the abdominal cavity; in this stage the prostate, the seminal vesicles and the terminations of the ureters are all exposed. After opening into the abdominal cavity we proceed to detach the pelvic part of the rectum; the lateral peritoneal folds are ligatured and divided; the posterior attachment of the rectum assumes more and more the character of a mesentery as we trace it up: it is in this mesentery that the branches of the superior hæmorrhoidal artery run to supply the bowel; they are to be securely ligatured and divided. The seat of the disease may oblige us to reach up as far as the pelvic colon; it is not difficult to isolate it and draw it down, because we have only the mesentery to deal with. Fig. 273 represents the progress we have made and the opening in the peritoneum; note that no opening has yet been made into the bowel.

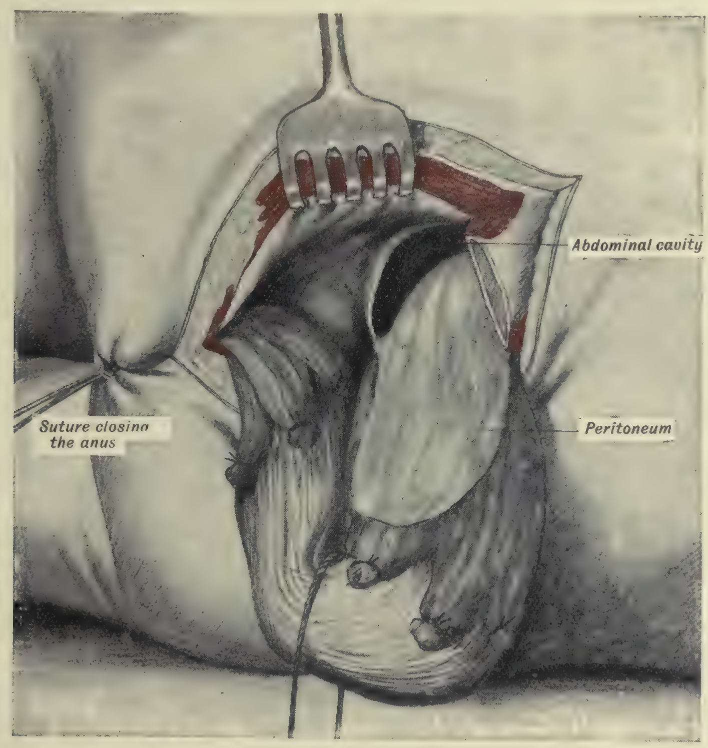


FIG. 273.—Resectio recti. I. Stage. The anus is stitched up tight. The incision is made, the coccyx resected and the rectum freed. The haemorrhoidal vessels are then ligatured and divided, the rectum drawn out and the peritoneal cavity opened.

The operator now pulls the intestine well down and closes the opening in the pouch of Douglas, stitching the edges of the peritoneum all round the bowel with a fine continuous catgut suture: a considerable part of the serous intestine is thus provided with a new extraperitoneal site. Pack a layer of gauze deeply into the upper angle of the wound in order to shield the peritoneum. The aseptic character of the operation can no longer be maintained. Do a temporary occlusion of the intestine high up with an elastic band or a strip of gauze and resect the diseased portion with large straight scissors (*v.* Fig. 274).

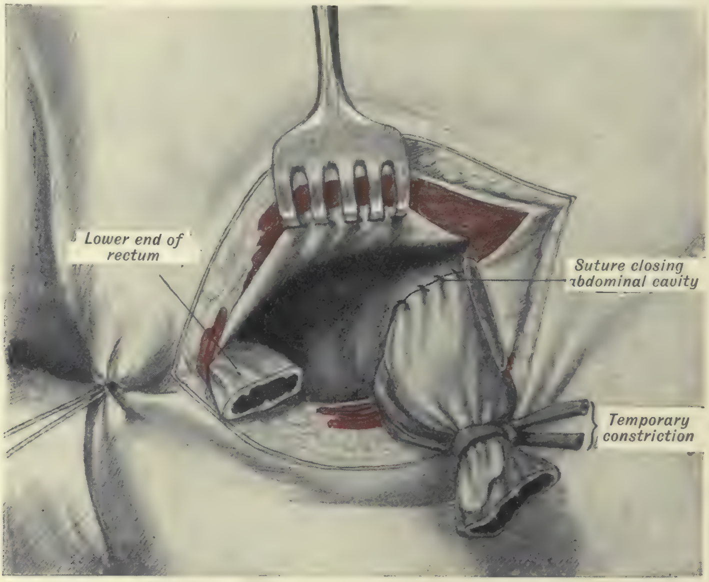


FIG. 274.—Resectio recti. II. Stage. A piece of the pelvic colon is brought down, and the peritoneal cavity reclosed. The proximal end of the gut is constricted provisionally and a large piece of the rectum resected in continuity.

The next step is to make a circular suture of the two stumps. Nevertheless a suture like this has the very poorest chances; the main reason for this is that the two ends are devoid of that serous coat which would ensure the rapid healing of the gut after suturing. Circular anastomosis is only performed (1) when the two ends can be coapted without tension, allowing of easy union with a double circular stitch, and (2) when it is possible to divide the meso-sigmoid so carefully that the superior hæmorrhoidal artery can be ligatured off *immediately* above the line of resection; this ensures the nutrition of the afferent end. Unfortunately these conditions are seldom complied with. For this reason we have a preference in Bier's clinic for Hochenegg's method: it has been already indicated in Fig. 272. Evert the anal end and completely strip it of its mucous membrane to where it joins the skin ; invert it once more and through this widened anal canal draw down the proximal cylinder of bowel. Sew the bowel securely at the anal ring and at the upper edge of the anal canal. This re-establishes the continuity of the intestine right through the sphincter. The operation is concluded by packing the wound cavity behind the rectum loosely with gauze (cp. Fig. 272).

10. *Extirpation of the Inguinal Glands.*

In dealing with diseased inguinal glands it is not necessary in every case to make a clean sweep of all the lymphatic fatty tissue in the groin ; partial excision is sufficient in suppurations and other benign affections of the glands. But a radical clearance is demanded in malignant affections. In carcinoma of the lower part of the rectum with infiltration of the anal skin and in carcinoma of the external genitalia, especially the penis, the inguinal glands must be cleared out with every bit as much care as is devoted to the axillary glands in cancer of the mamma. The typical skin incision is shown in Fig. 275. The first incision lies immediately above and parallel to Poupart's ligament ; a vertical cut is carried down from this to correspond to the position of the femoral vessels. The skin is then raised in flaps and is reflected upwards, outwards and inwards. Then incise along the upper oblique incision, through the subcutaneous fascia and down to the aponeurosis of the external oblique, and make a clean dissection of the gland-containing fatty tissue as far down as the saphenous opening. The great femoral trunks are stripped of all their fatty covering ; particular attention is paid to the vein, its side branches are ligatured and the internal saphenous vein ligatured and followed a short way downwards. Then divide the falciform edge of the saphenous opening, and trace the chain of lymphatics which can usually be felt running down in line with the femoral vessels. In discussing femoral hernia it was noted that the crural ring lay to the inside of the vein : it is to be opened up and cleared of all its fatty connective tissue

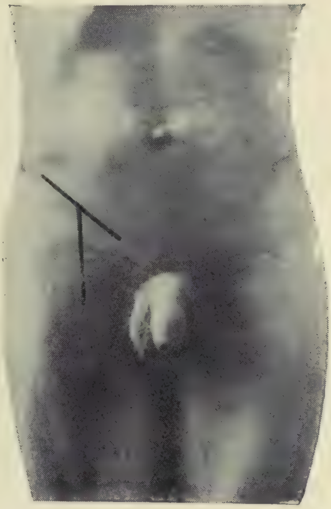


FIG. 275.—Incision for extirpation of the groin.

When there is reason to suspect that other glands are implicated along the external iliac artery and vein, we incise above Poupart's ligament and divide the three muscles of the abdominal wall and the fascia transversalis (as described in ligature of the external iliac) and follow up the iliac glands as far as is thought necessary; they lie behind the peritoneum. Carefully suture up the incision in the abdominal wall and close the opening in the fascia lata. Stitch the skin flaps back into place and insert a drainage tube for a day or two, for there is always a copious secretion of lymph and some oozing of blood.

SECTION VII

OPERATIONS ON THE ABDOMEN

INTRODUCTION

(*a*) *The various abdominal incisions.*

ABDOMINAL surgery occupies a prominent place in modern teaching, and a description of it belongs not merely to works on operative technique but also forms the essential preliminary to practice on the dead subject and animals. Abdominal incisions can be made either in the anterior or in the lateral belly wall. The median incision is always the best. It divides the linea alba between the recti muscles: at this point we encounter no vessels of any size, and what is more, no important nerves: in lateral abdominal incisions the nerves must be avoided as far as possible, so as to prevent the occurrence of muscular paralysis or dystrophy.

The anterior aspect of the belly wall is shown in Figs. 276 and 277. The ribs are seen curving upwards to unite near the ensiform process of the sternum: these infracostal margins form the upper boundary of the abdomen on either side. Another important landmark is the umbilicus. Poupart's ligament should be made out on both sides: it arises from the anterior superior spine of the ilium and is inserted into the pubic spine. Other distinctive features are the recti muscles and external to them, the lateral abdominal muscles.

Incision No. 1 in Fig. 276 denotes the line in which the abdomen is usually opened for exposing the stomach. It lies on a line between the ensiform process and the umbilicus. After dividing skin and subcutaneous fascia we come upon the closely matted fibres of the linea alba. The linea is broad enough at this point to be divided without it, being necessary to open the sheath of the rectus: indeed the recti do not come into view at all. The tissues are divided layer by layer; immediately the linea alba is divided a layer of loose fat comes into view; seize it with surgical forceps and cut slowly down till an opening is made into the abdominal cavity. Guard the viscera by introducing the fingers of the left hand and slit up the peritoneum with knife or scissors in the whole length of the incision, taking every possible care to preserve the abdominal contents ; catch up the edges of the peritoneum with several Mikulicz clamp forceps (Fig. 278). As soon as the peritoneum is opened blunt retractors should be substituted for the sharp ones, to prevent any injury to the abdominal viscera. The same care in opening the peritoneum should be taken in every incision into the abdomen. If the above incision does not sufficiently expose the stomach, it may be prolonged downwards and carried round the umbilicus on one or both sides. Incision No. 2 in Fig. 277 serves to expose the entire stomach : the transverse incision at right angles to the first one divides not only the muscles but also the cartilage of the infracostal margin. (Note that the pleura lies very near !)

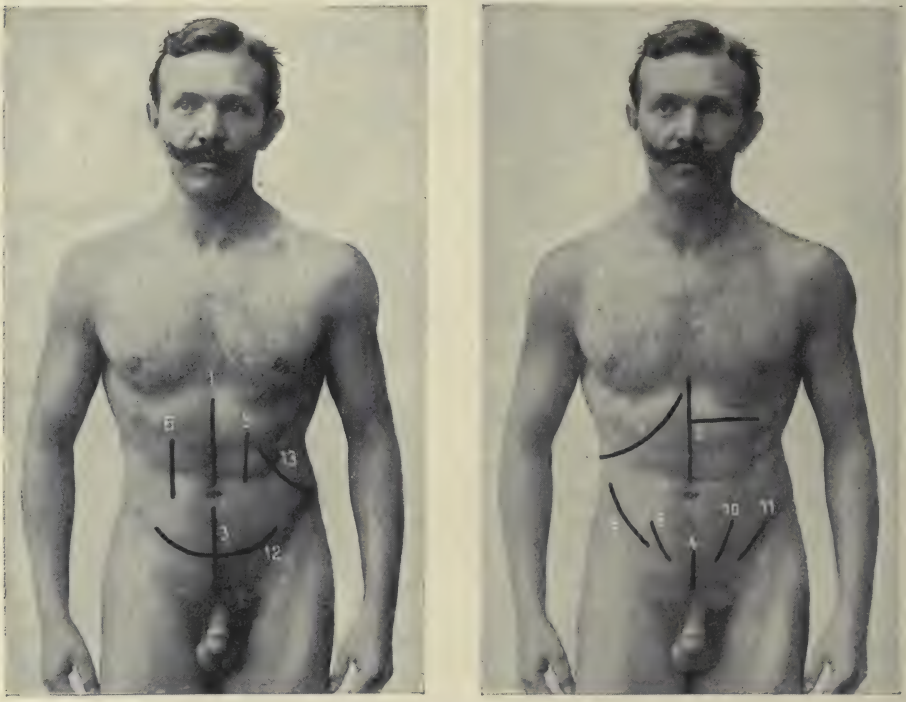


FIG. 276. FIG. 277.

Incisions in the anterior abdominal wall : 1. for the stomach ; 2. for fuller exposure of the stomach ; 3. for the small intestine ; 4. for the bladder ; 5. for gastric fistula ; 6 and 7. for operations on the biliary tract ; 8. for the appendix ; 9. for perityphlitic abscesses ; 10 and 11. for formation of an artificial anus ; 12. suprapubic transverse incision (after Pfannenstiel); 13. for the exposure of the spleen.

Incision No. 3 in Fig. 276 is used for exposing the small intestine, for draining peritoneal effusions and for treating kinks in the bowel from any cause. No. 4 in Fig. 277 is for the extra-peritoneal exposure of the bladder. These incisions (Nos. 3 and 4) are made between the umbilicus and the symphysis ; they divide skin and fat and expose the anterior sheath of rectus in the mid line. The sheath is then divided and the inner edges of the recti muscles exposed (the linea alba is narrow and not at all well marked below the umbilicus) ; separate the recti with the blunt end of the knife, and divide first the posterior sheath of the rectus together with the transversalis fascia and then the peritoneum. In the bladder incision the small pyramidalis muscles are met lying in front of the recti. (Compare also Fig. 416.)

Incision No. 5 in Fig. 276 is in order to establish a gastric fistula. A linear incision is made through skin, fat and the anterior sheath of the rectus, and the longitudinal fibres of the rectus muscle are bluntly separated with the handle of the knife. Any nerves that happen to cross the field of operation should be displaced upwards or downwards. On reaching the back of the rectus muscle one has to divide the terminal fibres of the transversalis abdominis. Then divide the transversalis fascia and the peritoneum.

Incision No. 6 in Fig. 276 exposes the gall bladder. It is carried out precisely as in the gastric fistula incision No. 5, except that it is usually somewhat longer. This incision must be enlarged in operating on the deep biliary passages ; incision No. 7 in Fig. 277 is then required. The incision runs some two finger-breadths or less below and parallel to the costal margin and penetrates all the abdominal layers, dividing the outer half of the rectus muscle and the three abdominal muscles. The incision can scarcely be called conservative, but it affords a splendid view of the parts ; it has been modified in a variety of ways.

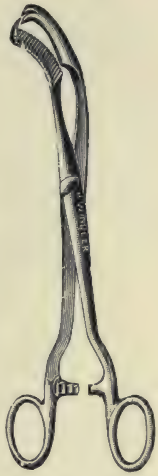


FIG. 278.—Clamp forceps for the peritoneum (v. Mikulicz's).

Incision No. 8 in Fig. 277 is the simplest and best method of exposing the vermiform appendix (Lennander's incision). Make a somewhat oblique incision through skin and subcutaneous fat to correspond with the outer border of the rectus abdominus muscle ; it commences a little above a line drawn from the umbilicus to the anterior superior spine ; this line should divide the incision into more or less equal halves ; the extent to which the cut is prolonged downwards depends greatly on the thickness of the abdominal wall and more especially on the quantity of fat. Divide the tendon of the external oblique muscle and expose the anterior sheath of the rectus. The outer edge of the rectus muscle is seen shining through the aponeurosis of the external oblique. Make an oblique incision through the aponeurosis half an inch to the outside of the rectus muscle. Then free the rectus by means of blunt dissection and retract it inwards. The posterior sheath of the rectus and the peritoneum should then be divided in line with the anterior incision but a little further inwards. This stage of the operation is represented in Fig. 279. This abdominal incision appears at first sight somewhat complex, but it is really quite simple. The final result is that the rectus muscle comes to lie between the two layers of aponeurotic sutures and the way to a ventral hernia is thus blocked. Any nerve strands that come into view should be preserved by pushing them either upwards or downwards. If the incision is prolonged downwards we come upon the deep epigastric vessels slanting upwards and inwards to disappear behind the edge of the rectus muscle; in unusually low incisions they must be double ligatured and divided. In suturing the pararectal incision we should catch up in our deep layer the peritoneum, transversalis fascia and posterior sheath ot the rectus; the second layer is passed through the anterior sheath of the rectus and the tendon of the external oblique; the third layer is the skin stitch. In fat abdomens an extra row of sutures will be required for the fat and subcutaneous fascia, in order to avoid empty spaces. (It is to be noted, however, that the posterior sheath of the rectus is deficient below a point midway between umbo and symphysis.) The pararectal incision can be carried out in a variety of intestinal operations; it may be extended at will, and is applicable to the left as well as to the right side.

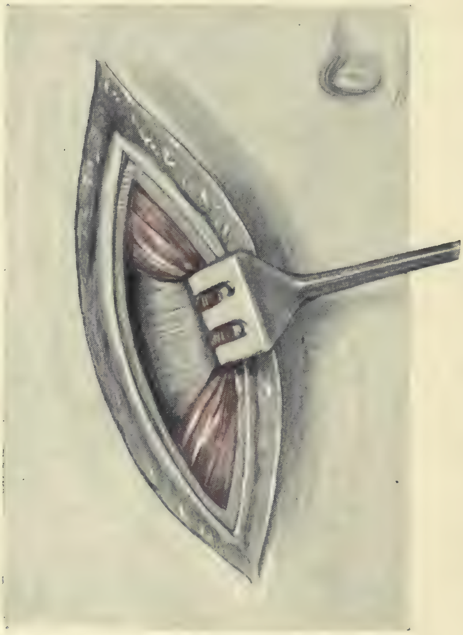


FIG. 279.—Lennander's pararectal incision.

Another rather complicated method is the muscle-splitting incision of McBurney (gridiron incision). It is specially designed to conserve the nerves. The lateral abdominal muscles are divided exactly in the line of their muscle fibres. It is a physiological incision, and if primary healing takes place it offers the surest protection against post-operative ventral hernia. The skin incision corresponds pretty much to No. 9 in Fig. 277, *i.e.* it runs three fingerbreadths above and more or less parallel to Poupart's ligament. The incision exposes the external oblique muscle (generally in its tendinous portion, Fig. 280). The muscle is then divided and loosened up on each side until it can be stitched to the skin with a stout silk suture (Fig. 281). The internal oblique and transversalis muscles are now seen running obliquely to the fibres of the external oblique. The two deep muscles should be divided by splitting them in their tendinous portion in the line of their fibres, a part of the anterior rectal sheath being divided at the same time. Force the muscle fibres apart with the handle of the knife and a pair of retractors (Fig. 282) and evert them also with stout stitches; a fold of skin may be caught up above and below the cutaneous incision. We have thus a wound rhomboid in shape and we next proceed to open the fascia transversalis and peritoneum in its widest diameter. After finishing

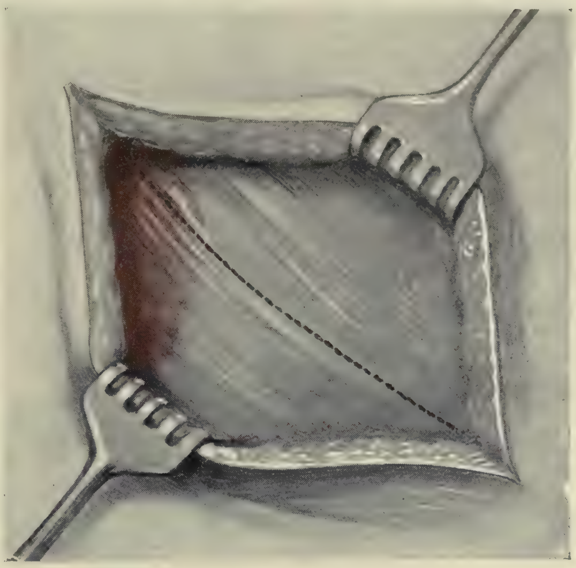


FIG. 280.—McBurney's muscle-splitting method. I. Stage. Exposure of the external oblique, followed by splitting of its fibres along the dotted line.

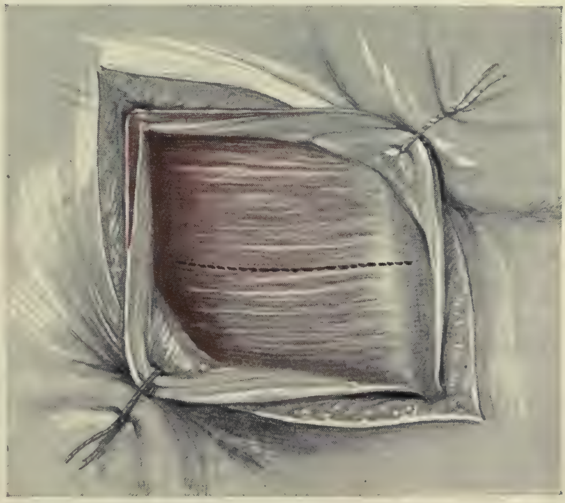


FIG. 281.—McBurney's muscle-splitting method. II. Stage. Catch up the edges of the external oblique, and make a blunt dissection through the deep musculature in the dotted line.

off the operation on the appendix close the peritoneum with a first layer of sutures, remove the stay sutures and approximate the deep oblique musculature with a second, close the external oblique with a third, and suture the skin and subcutaneous tissue with a fourth.

Incision No. 9 in Fig. 277 is employed for caecal abcesses and in resection of the caecum. It is not carried beyond the middle of Poupart's ligament; it divides all the abdominal muscles. It is not easy to preserve the nerves in every case, especially if a large opening is required.

Incisions Nos. 10 and 11 in Fig. 277 aim at establishing an artificial anus or a fistula of the great bowel. No. 10 is the exact counterpart of the appendix incision, and No. 11 is a short incision that runs parallel to Poupart's ligament and divides skin and soft tissues.

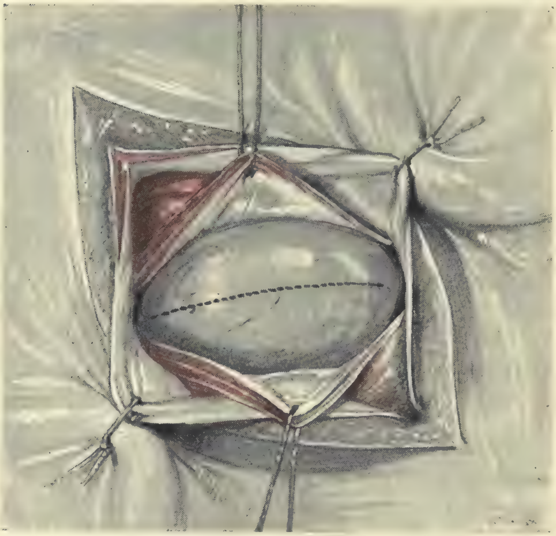


FIG. 282.—McBurney's muscle-splitting method. III. Stage. Retract the deep musculature apart; open the peritoneum to correspond to the dotted line.

Incision No. 12 in Fig. 276 corresponds to the suprapubic transverse incision of Pfannenstiel. It is a complicated method, much employed in gynaecology. It is planned to prevent the occurrence of rupture and to conceal the scar in the transverse fold of the abdomen. Make a large curved incision opposite the semilunar fold of Douglas, divide the anterior rectal sheath in the same line and carry the incision to the outer side of both recti. Then free the anterior sheath of the rectus from the rectus muscle, using blunt dissection except at the points where the muscle is attached to the aponeurosis, and throw the sheath upwards and downwards in the form of two aponeurotic flaps. It is now easy to separate the recti from each other and make a linear cut through the fascia transversalis and peritoneum. The incision is sutured up in the reverse order of the layers. The lines of suture cut across one another only at one point.

Incision No. 13 in Fig. 276 represents one way of exposing the spleen. Commence at the left border of the rectus, keep a distance of two finger-breadths from the costal margin and divide all the soft tissues of the abdominal wall.

(*b*) *Technique of abdominal suture.*

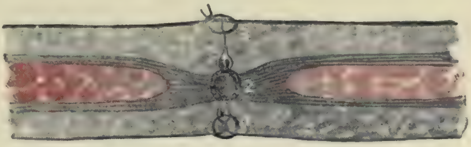


FIG. 283.—Suture of the abdominal wall, in the linea alba above the umbilicus. 1. Suture of the peritoneum; 2. of the linea alba; 3. of the skin.

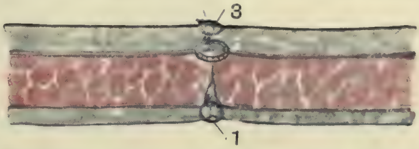


FIG. 284.—Suture of the abdominal wall in the mid line below the umbilicus: 1. Suture of the peritoneum, fascia transversalis and posterior sheath of the rectus; 2. of the anterior sheath of the rectus; 3. of the skin.

To achieve successful results we have not only to carry out the correct abdominal incision but also to make an artistic suture of the abdominal wall. Every abdominal incision is closed in layers, *i.e.* every layer is sutured in the reverse order to which it was opened. Accordingly we begin by carefully closing the peritoneum with a continuous catgut stitch, laying the peritoneal edges back to back to prevent adhesions. An accurate and smooth closure of the peritoneum must be secured in every case. We shall find it of assistance to catch up the edges of the peritoneum with Mikulicz forceps as soon as it is opened; they are not to be taken off till the end of the operation. The second and most important row of sutures unites the muscles and aponeuroses of the belly wall. Ventral hernia will probably ensue if this suture is not made stable and secure; we shall describe it immediately. The third and last row of sutures unites the skin and the subcutaneous tissue. Suture of the muscular and aponeurotic layers of the abdomen is affected most easily in median laparotomies above the umbilicus; the method in vogue for operations on the stomach has been described and is represented in Fig. 283. As soon as the peritoneum has been sutured the edges of the linea alba are caught up with a strong suture (continuous or interrupted) and drawn firmly together. Finer material can be used for stitching the skin. In all cases where we have exposed the recti muscles and penetrated between the muscle fibres (*e.g.* in the incisions 3, 5 and 6 in Fig. 276), we do the suture in a different way. It is then best to stitch up the posterior sheath of the rectus along with the transversalis fascia and peritoneum and make this the first suture layer. It is not the slightest use to stitch up the longitudinal split in the muscles, for the muscles fibres fall together of themselves; on the other hand the greatest attention should be paid to the anterior sheath; it must be sutured with strong material without any gaps being left. Such an abdominal suture is shown in Fig. 284.

A third method of abdominal suture is indicated when the muscles have been divided transversely across, *e.g.* in incisions 7, 9 and 13 in Figs. 276 and 277; every muscle that has been divided in this way must have its cut edges carefully approximated and stitched together. Suture up the transversalis fascia and peritoneum to form the first layer, suture the various muscles along with the anterior sheath of the rectus to form the second layer, and suture the skin to form the third layer. This suture is shown in Fig. 285. When the condition appears to demand it, a special suture can be introduced into the muscles and another one into the aponeurosis. Everything depends on making the closure an absolute one.

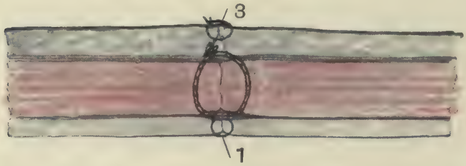


FIG. 285.—Suture of a transversely divided abdominal wall: 1. Suture of the peritoneum and fascia transversalis; 2. of muscle and anterior aponeurosis; 3. of the skin.

In cases where extra security is a desideratum a deep abdominal suture can be added to the triple suture above described and tied externally over a thick layer of gauze. This method is employed where the abdominal tension is high or where post-operative tension is feared. The technique is as follows:—Suture peritoneum and transversalis fascia in the usual way with a continuous suture, thus closing the abdomen. Then thread a wire suture (aluminium-bronze) on a stout needle and pass it deep through skin, aponeurosis and muscles, bringing it back through the opposite side some distance from the edge of the wound. These sutures lie about 1 in. apart (3 cm.) and are at first left untied. Then stitch up the aponeurosis and the skin, and finally draw the wire sutures somewhat forcibly together over a cylinder of gauze. The deep sutures act splendidly. They relieve the other stitches and prevent the occurrence of bleeding between the various abdominal layers (*v* Fig. 286). The methods in use for suturing the more complicated incisions (pararectal incision, muscle-splitting incision) have been already described.

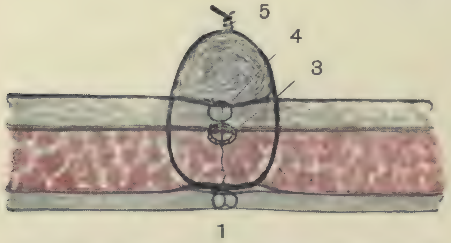


FIG. 286.—Suture of the abdominal wall with through-and-through wire stitches, tied over a roll of gauze: 1. Suture of the peritoneum and fascia transversalis; 2. introduction of wire through all the other layers; 3. suture of the anterior aponeurosis; 4. suture of the skin; 5. twisting of the wire over a roll of gauze.

(*c*) *Topographical sketch of the abdominal viscera.*

Before operating on the abdomen, it is well to make a small incision and become acquainted with the normal conditions. Palpation can be done with the finger or with the whole hand whenever we find that the view obtained through the wound is insufficient. It is often possible also to draw the abdominal contents out of the wound to the front of the abdomen. Operations should be carried out in front of the abdominal wall as far as practicable; on the completion of the operation, *e.g.* after enteroraphy, the viscera are replaced in the abdomen.

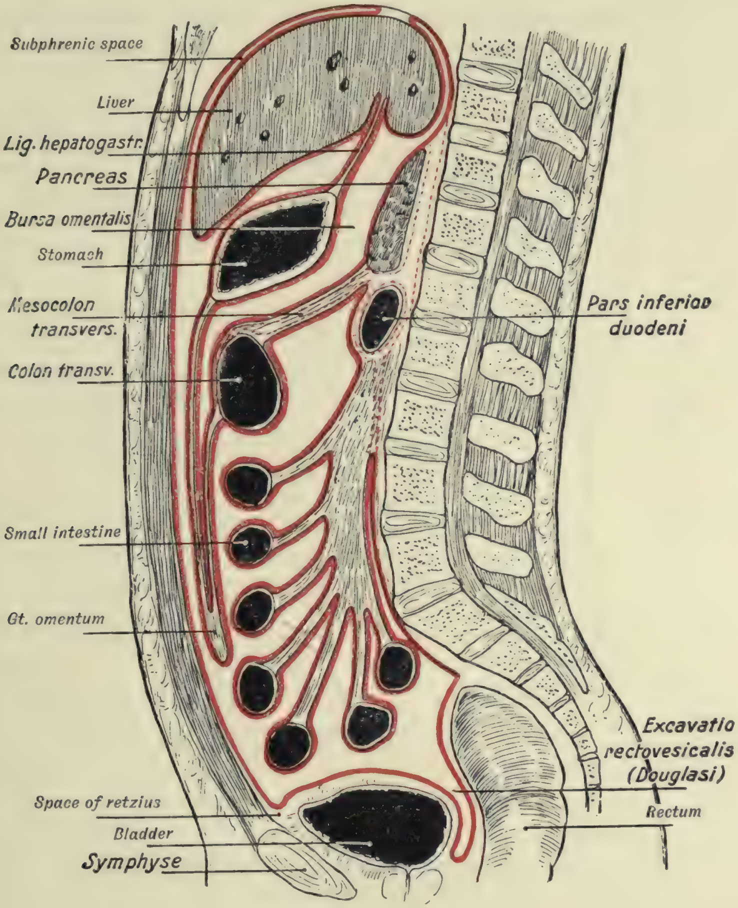


FIG. 287.—Sagittal section of the abdomen, to illustrate the course of the peritoneum. (After one of Sobotta's diagrams.)

In correlating the abdominal viscera we should keep the two diagrams. Figs. 287 and 288, before our eyes. Fig. 287 is a sagittal section and shows the course of the peritoneum in the middle line of the body. It lines the subphrenic space, is reflected on to the liver, crosses on the gastro-hepatic omentum to the anterior surface of the stomach, sweeps over the great omentum, posterior surface of the transverse colon and transverse mesocolon, and clothes the mesentery and all the coils of small intestine ; it then invests the anterior surface of the rectum, is folded as the pouch of Douglas (plica recto-vesicalis) on to the cupola of the bladder, misses the space of Retzius and runs on to the anterior belly wall as the plica prevesicalis. We have thus a completely closed peritoneal sac. There is still another sac of peritoneum behind the stomach, the lesser sac of the peritoneum (Bursa omentalis). In Fig. 287 it appears as a closed and independent part of the peritoneum. In reality, however, it communicates with the general sac of the peritoneum through the foramen of Winslow ; this opening lies on the right side of the median line and passes into the lesser sac behind the hepato-duodenal ligament, the hepatic vessels and the common bile duct. Note particularly the way in which the edge of the liver projects beyond the

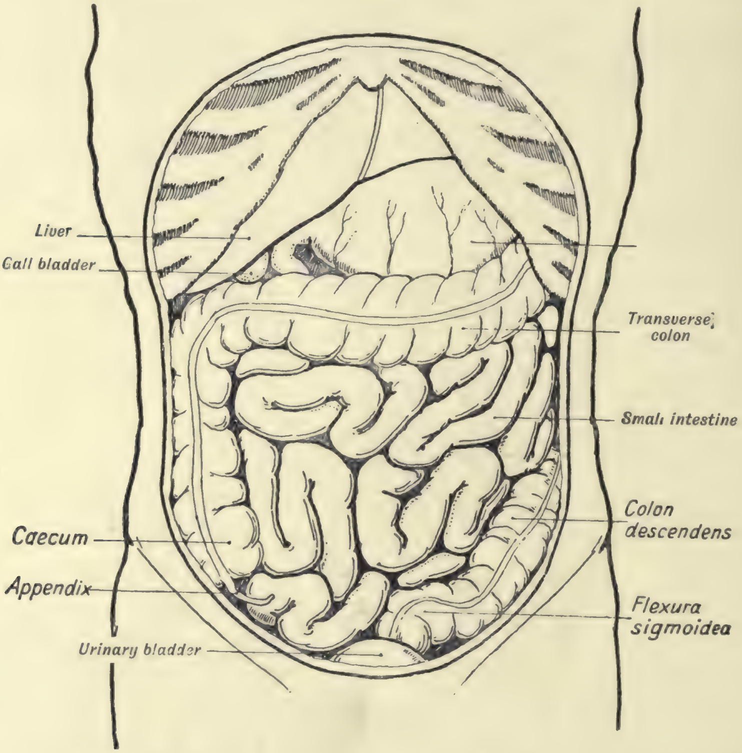


FIG. 288.—Relations of the abdominal viscera. A large window has been cut in the abdominal wall ; the large omentum has been omitted from the drawing.

sternum and partially overlaps the stomach ; note also that the anterior surface of the stomach is directly accessible as soon as the abdomen is opened, but that its posterior surface cannot be reached except by separating the great omentum from its attachment or by penetrating below the transverse mesocolon. Observe also that the coils of small intestine, the mesentery and the lower aspect of the transverse colon are all covered over by the great omentum and cannot be exposed till this abdominal shawl is lifted up. Assure yourself also as to the position of the duodeno-jejunal flexure of the small intestine ; it is fixed in the root of the mesentery and bears a close anatomical relation to the pancreas.

Another diagram is given in Fig. 288. It displays the abdominal contents as seen from the front after a large window has been made in the abdominal wall and the great omentum completely removed. It gives one a particularly good idea of the position of the great intestine ; the liver, gall bladder, stomach, small intestine, appendix and urinary bladder are also seen. Compare this figure with the abdominal sections in Figs. 276 and 277, and you will understand how the different organs can be reached by means of the incisions already described.

(*d*) *The technique of enteroraphy, lateral anastomosis and Murphy's button.*

The essential condition for the practice of gastric and intestinal surgery is to master the technique of intestinal suture. It can be practised on the living intestine, in the dog, or on the fresh intestine of a pig ; or it may be tried on the dead subject if the peritoneum has been newly opened and found normal. If a piece of bowel shows signs of decomposition it tears away on manipulation, and is therefore rendered useless for the purpose.

Our instrumentarium consists of fine, round, curved needles (Fig. 290) ; they are held in a short needle holder. This holder should be kept in working order and reserved for fine needles, for its exactness and certainty go for nothing if it is employed for coarser stitches (Hagedorn's needle holder is shown in Fig. 289). The

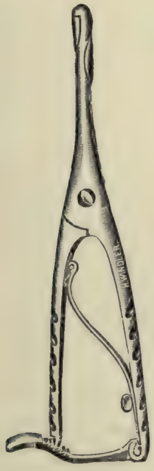


FIG. 289.—Intestinal needle-holder (Hagedorn's).

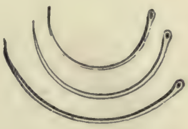


FIG. 290.—Round intestinal needles.

finest silk is used, and the needles must be sharp enough to perforate the delicate intestinal wall without its being necessary to fix the wall with forceps or to force the needle through. The operator carries a pair of fine surgical forceps in the left hand, but this is only done to support the gut and care should be taken not to damage the serous coat in the very slightest. Intestinal sutures should be passed easily and firmly; each puncture should be done with decision and only the once; there must be no fumbling and pricking. The tissues should be damaged as little as possible and the points at which the needle enters and leaves should not be visible. Steer clear of the vessels. The intestinal contents must be stroked away from the affected part and every effort made to work on an empty bowel. Fig. 291 shows how the bowel is gently stroked with the second and third finger and emptied of faeces. The faeces are held back by occluding the bowel with a fine Doyen's intestinal clamp (Fig 292), which renders the bowel bloodless at the same time. Fig. 293 illustrates the catching up of a fold of intestine with the

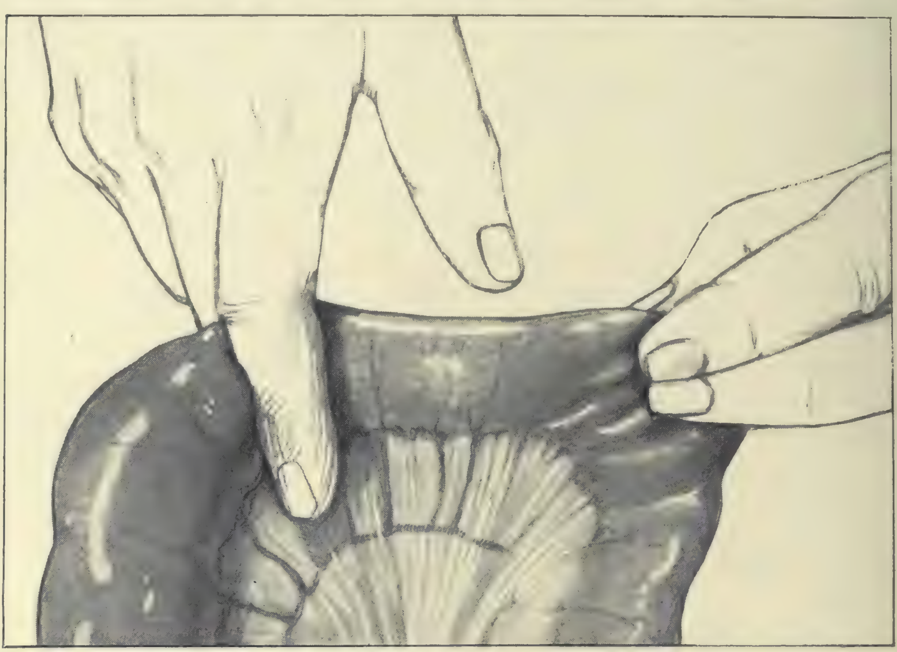


FIG. 291.—Stroking out of the intestinal contents with the fingers.

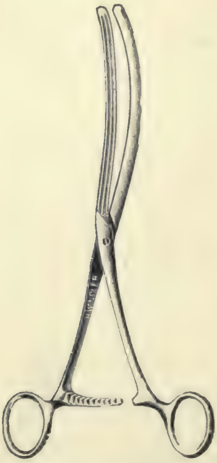


FIG. 292.—Delicate intestinal clamp (Doyen's).

intestinal clamp; the clamped portion is deprived of both its faeces and its blood. Fig. 294 shows the clamping of a coil of bowel with its mesentery; the mesentery, however, is a delicate structure and often allows the blood to pass through. If an intestinal clamp is not to hand a good substitute is to pass a strip of gauze through a hole in the mesentery and bind it loosely round the gut (*v.* Fig. 295). These intestinal clamps are yielding

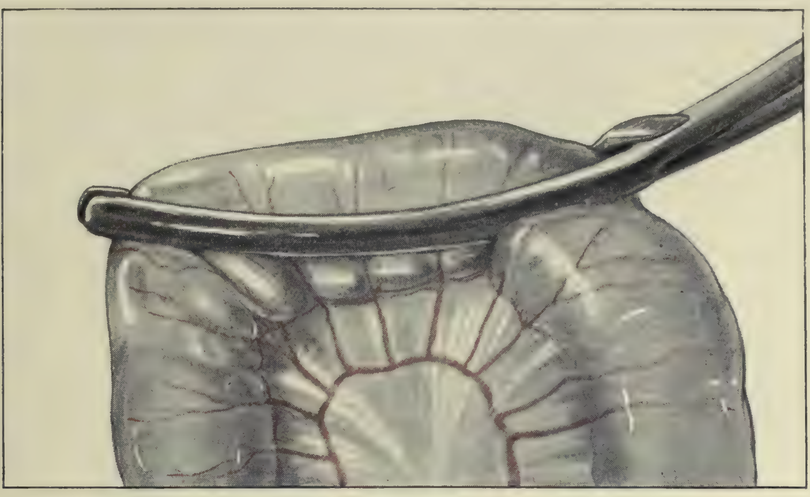


FIG. 293.—Seizure of a fold of intestine with the Doyen's clamp.

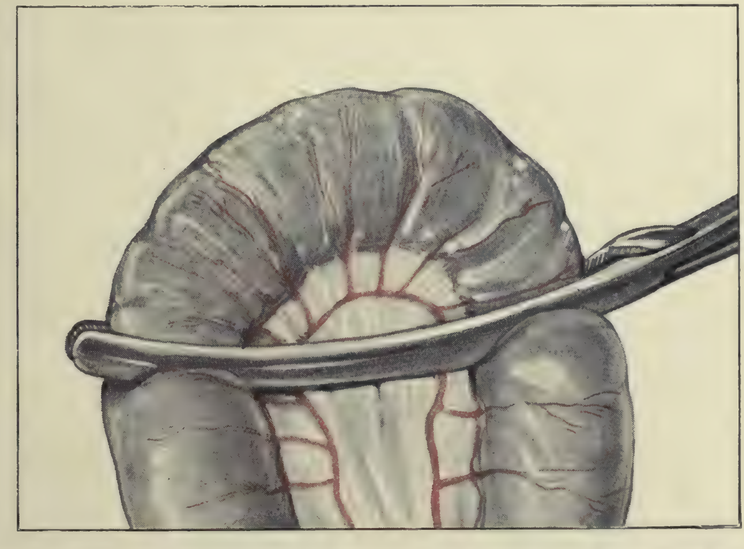


FIG. 294.—Seizure of an intestinal coil and associated mesentery with the Doyen's clamp.

and elastic, and should not do even the slightest injury to the wall of the gut. The effect of the crushing clamps is quite different; Kocher's form of instrument is shown in Fig. 296. They crush the gut at the place where it is to be divided, or are used for closing the ends of the bowel when parts

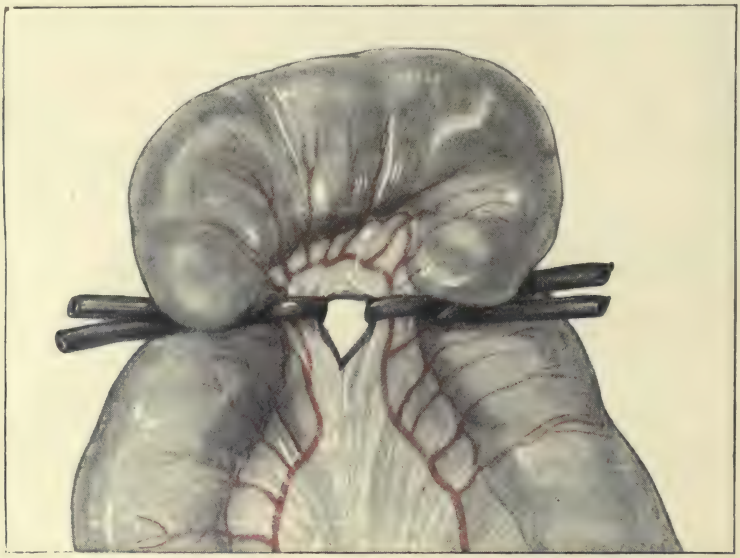


FIG. 295.—Binding off the intestine with rubber bands passed through an opening in the mesentery.

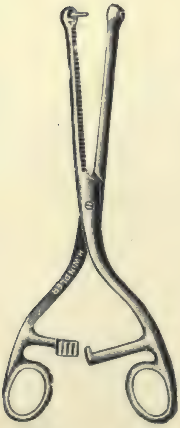


FIG. 296.—Kocher's intestinal clamp.

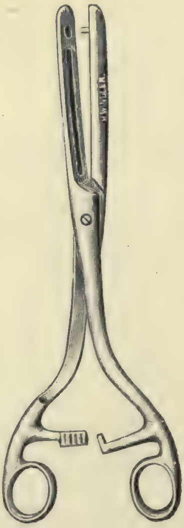


FIG. 297.—Graser's intestinal crushing forceps.

of the intestine are being resected. Graser's is a clamp of a similar type (Fig. 297), and its method of application is illustrated in Fig. 310.

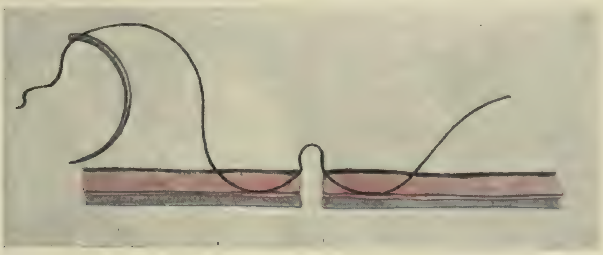


FIG. 298.—Lembert's single intestinal suture. Introduction of the stitch.

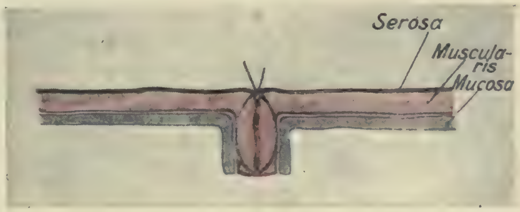


FIG. 299.—Lembert's single intestinal suture. The stitch is shown tied.

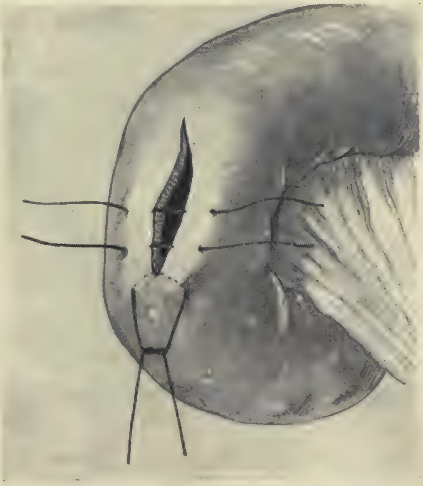


FIG. 300.—Lembert's sutures applied to an opening in the small intestine.

Lembert's intestinal stitch is employed for uniting pieces of an intestine that has been divided. It has a host of variations both for gastric and intestinal suture, but the main principle is common to all; it rests upon a recognition of the fact that the serous surfaces are the first parts of the intestinal wall to be sealed by the formation of a plastic exudate and united by the proliferation of connective tissue. Accordingly two broad layers of the serous coat should be stitched back to back. Figs. 298 and 299 give a diagrammatic representation of the Lembert suture. Enter the needle about $\frac{2}{5}$ in. (1 cm.) from the cut edge, pass it through the serous and muscular coats and out again to the serous surface at the cut edge; on the side opposite enter the stitch at the cut edge and bring it out at a corresponding point 1 cm. therefrom; the needle misses the mucous membrane. On tying this we get a sero-serous suture and the mucous membrane vanishes, being folded into the lumen of the gut. Fig. 300 represents a single Lembert suture of the small intestine. Lembert's stitch is generally effective for the whole of the intestine. The only objection to it is that bleeding may take place from the free edges of the mucosa and submucosa into the lumen of the gut; this is of small amount, however, if the thermocautery is used for dividing the bowel and every vessel is ligatured as you come to it. The material is silk; the sutures are interrupted and are tied firmly $\frac{1}{5}$ in. ($\frac{1}{2}$ cm.) apart.

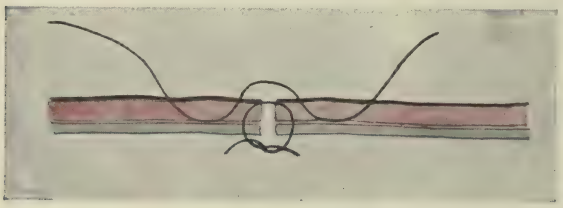


FIG. 301.—Double intestinal suture. Introduction of the stitches.

A double suture can be secured by stitching up the mucous membrane separately. This is only done when it is desirable to prevent every trace of bleeding, or when extra security is held to be a requisite. It is used for the stomach and great intestine; in the latter, however, the healing takes place less surely and quickly than in the small intestine. This double suture is seen in section in Figs. 301 and 302. The mucous membrane can be stitched with fine continuous catgut. This is the double suture of Czerny; many surgeons consider it the ideal method in gastro-intestinal surgery.

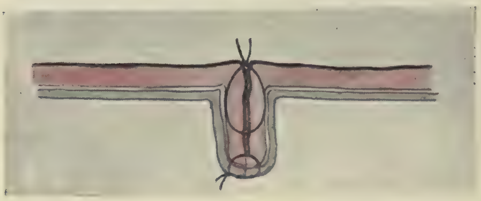


FIG. 302.—Double intestinal suture. The stitches have been tied.

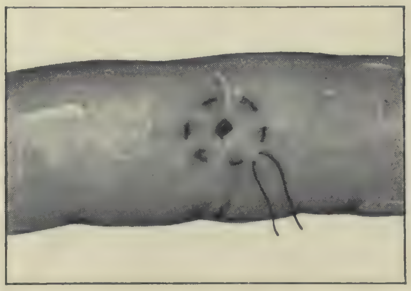


FIG. 303.—Purse-string suture for closing a hole in the intestine. Invagination follows.

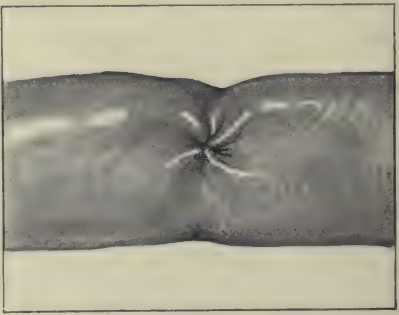


FIG. 304.—Purse-string suture tied.

We regard anything beyond the double suture as quite superfluous.

Indeed, it may be positively injurious in circular sutures of the small intestine and in the case of the pylorus, for it favours stenosis. Multiple invagination is only occasionally advisable; the procedure is used in cases where ends of bowel have to be closed, and is especially good for the great intestine.

Small openings in the intestine, *e.g.* stab or bullet injuries, can be closed by encircling the perforation with a purse-string suture, stitching only the sero-muscularis and invaginating the edges of the wound before tying the suture (*v.* Figs. 303 and 304); if this is done correctly the opening will be securely closed. If additional security is thought necessary introduce a transverse row of Lembert's sutures over the opening; by stitching transversely we avoid the risk of stenosis; linear stitching might lead to constriction. Larger openings in the gut, as shown in Fig. 306, should always be pulled out in the transverse axis of the gut, and then stitched into line with a row of Lembert's. Instead of being narrowed the wound is if anything widened. If the wound is still larger or the bowel has been crushed resection is usually indicated (see below).

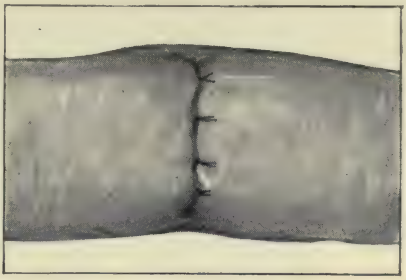


FIG. 305.—Cross stitching of the invaginated suture.

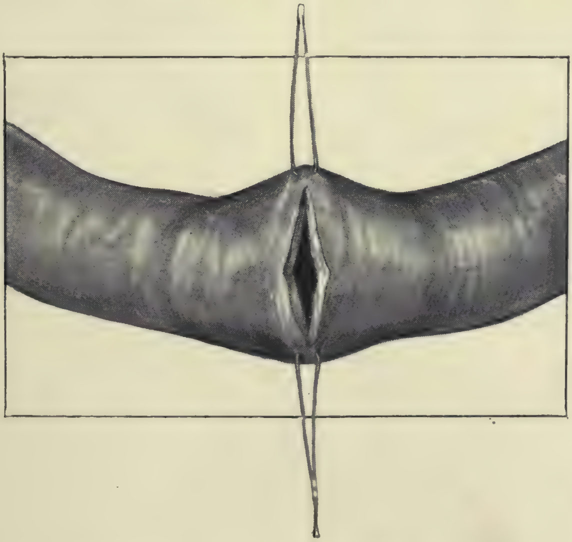


FIG. 306.—Retraction out of a largish opening in the bowel with a view to stitching it across.

Intestinal sutures should only be carried out in parts of the bowel where the circulation remains undisturbed. The mesentery should always be carefully examined in impacted hernias in view of the possibility of thrombosis of the vessels.

All gastro-intestinal sutures can be done effectively and well with the ordinary straight sewing needles ; they are especially useful for continuous double sutures. Fig. 307 represents how the ordinary sewing needles can be used for closing the lumen of the small intestine with a continuous double suture.

Another very simple method of occluding the intestine is shown in Fig. 308. Free a part of the bowel from its mesentery and doubly ligature it. Divide it between the ligatures with the thermocautery. The short projecting end should now be sunk deep into the lumen and covered over with peritoneum. The best way of doing this is by means of the purse-string suture. Carry a suture round the end of the gut at a distance of at least $\frac{2}{5}$ in., catching up only the serous and muscular coats and never entering the lumen ; compare Fig. 308. Previous to knotting off the suture, the assistant should press the apex of the gut into the lumen with a pair of forceps, so that it remains hidden after the stitch is tied.

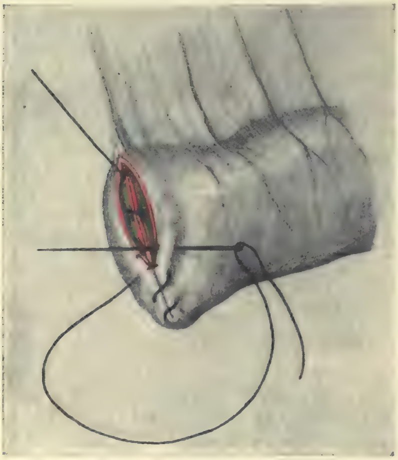


Fig. 307.—End-closure of the small intestine with double continuous stitch (ordinary seamstress needle).

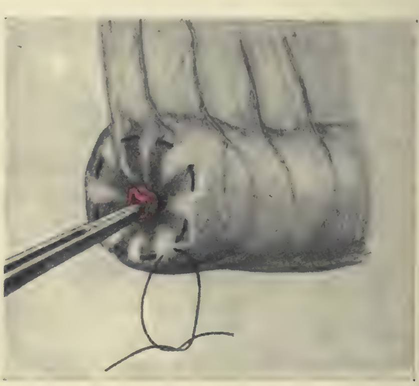


Fig. 308.—Invagination of a stump of bowel with the purse string suture (Doyen's).

We shall now refer to an instrument that is of assistance to us in surrounding the bowel with a ligature. This is the enterotribe shown in

Fig. 309. It crushes the bowel forcibly and the only part that is left at the point of the intended suture is a thin flap of serosa; a fine suture should then be passed round the bowel at this point.

End-closure of the small intestine is easy. In the large intestine the difficulties are greater. This can easily be understood from the irregular form of the large intestine, the infectious nature of its contents, the presence of appendices epiploicae, and, above all, owing to the absence of free mesentery from many of its parts. In the case of the small intestine, we can sometimes rest content with a single Doyen's purse-string suture, but this will not do for the large intestine; several invaginating sutures are required, and it is always well to stitch a piece of omentum over the line of suture. If we are not sure of our end-closure, it is advisable to

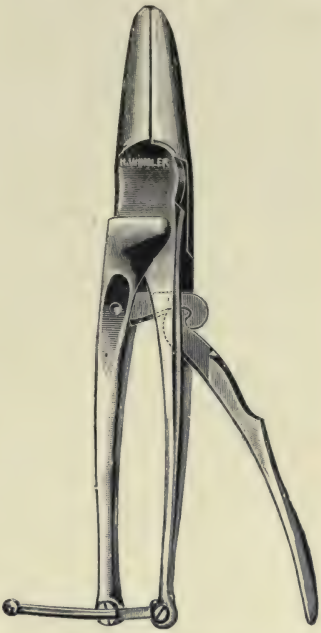


FIG. 309.—Enterotribe (intestinal crushing clamp).

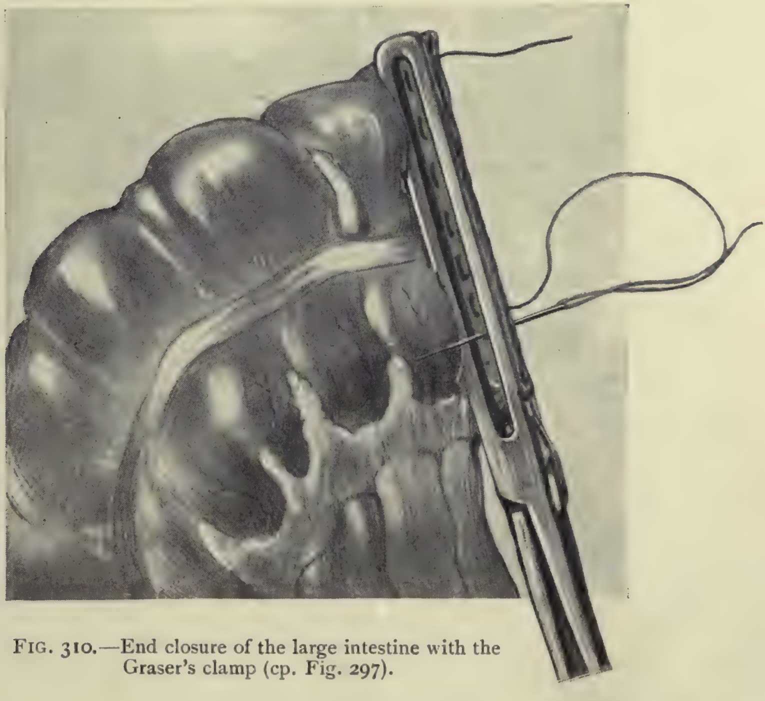


FIG. 310.—End closure of the large intestine with the Graser's clamp (cp. Fig. 297).

stitch this part of the bowel to the peritoneum and leave the abdominal wound open, then if the perforation does occur it will be to the surface. In the technique of the end-closure of the large intestine Graser's clamp will be found of great service (*v.* Fig. 297 above); the needle is passed through the arms of the clamp in the initial closure (*v.* Fig. 310), and this is followed by multiple invagination.

In gastro-intestinal surgery we are obliged in numerous instances to perform lateral anastomosis of two lumina for short-circuiting purposes or in order to unite the ends after a part of the bowel has been excised. Lateral anastomosis is therefore the first intestinal operation for the surgeon to master. The lateral anastomosis of two coils of small intestines is here described and illustrated. Seize each coil with a fine intestinal clamp and lay the clamps side by side. The amount of bowel caught up on each side must be of equal length and breadth, compare Fig. 311; the intestinal contents must also be stroked out as far as possible from the coils to prevent any gross soiling of the operation area. But it is as inadvisable to clamp off too little as too much of the gut, for there will not be sufficient room for stitching purposes and the sutures will tear. The clamps are depicted in Fig. 311; they enable the surgeon to gain control of the bowel, and the pressure causes no injurious results if the arms are sufficiently elastic; but care must be taken to exclude all the intestinal contents and devascularize the area of operation. The clamps are now fixed parallel to one another, and the operator makes an incision about 2½ in. (9 cm.) long in the two pieces of bowel; the two incisions are placed on the side away from the insertion of the mesentery; they are made carefully layer by layer so as to divide only the serous and muscular coats; the submucous and mucous coats remain unopened for a time. The posterior Lembert suture is now introduced (*v.* Fig. 311); this is an interrupted suture which accurately coapts the serous edges. After the posterior line of sutures, two important end-stitches are introduced at the two angles of the wound; they are shown in Fig. 312. Beginning at the end of the sero-muscular incision, make a long Lembert's stitch in the long axis of the bowel, and do the same on the other side (*v. a* in Fig. 312). The tying of this stitch ensures that the angle of the wound will not be too loose. This longitudinal stitch is followed by a transverse one, it is made at the corner of the wound and belongs really to the anterior line of sutures (*v. b* in Fig. 312). The ends of these last two sutures should be left long and the sutures themselves pulled up taut. The operator now takes the thermocautery and opens the bowel between two forceps, slowly burning through the mucous membrane in the lines of incision. The corner sutures are drawn taut, and

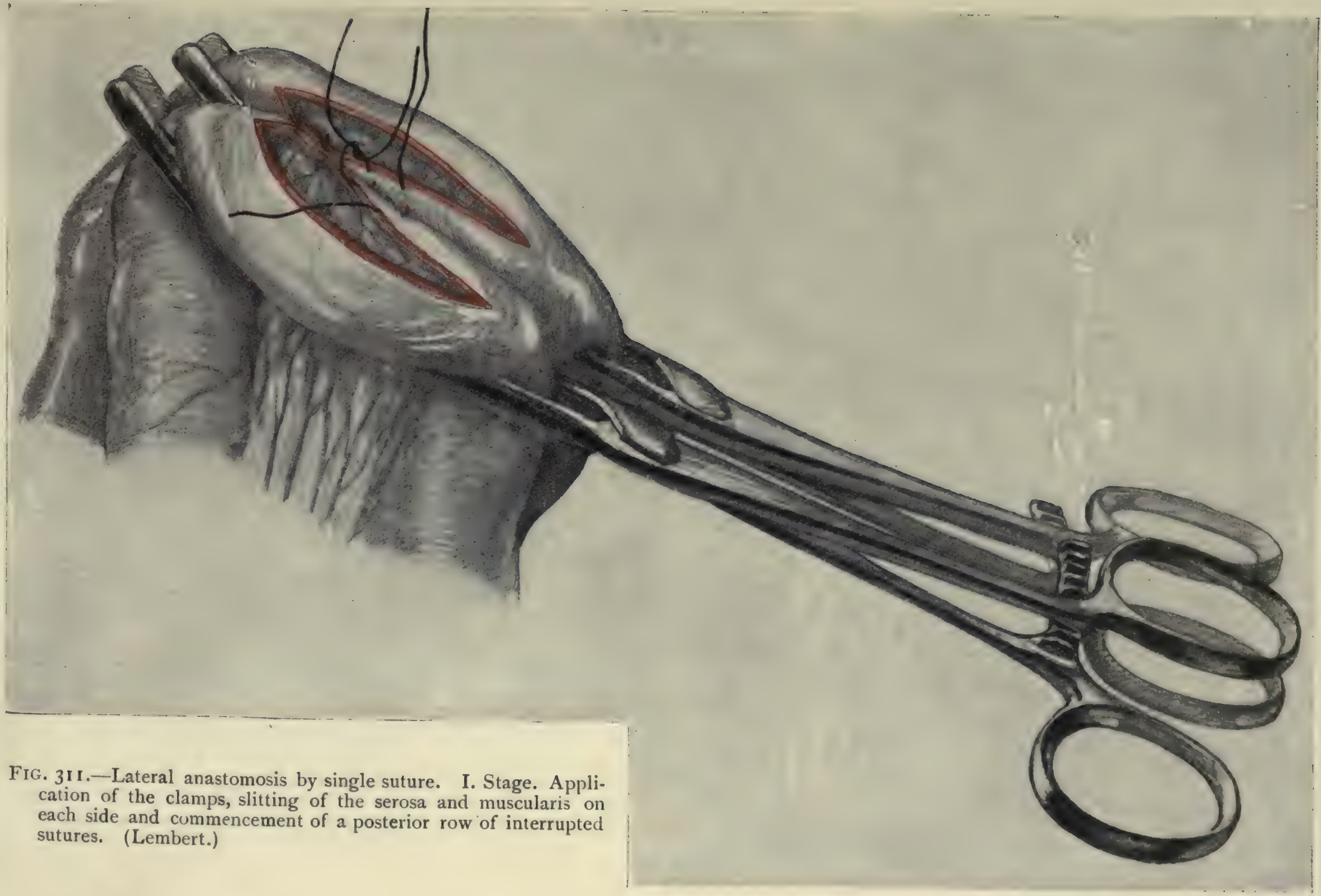


FIG. 311.—Lateral anastomosis by single suture. I. Stage. Application of the clamps, slitting of the serosa and muscularis on each side and commencement of a posterior row of interrupted sutures. (Lembert.)

prevent any unnecessary gaping of the openings and outpouring of faecal material (Fig. 313).

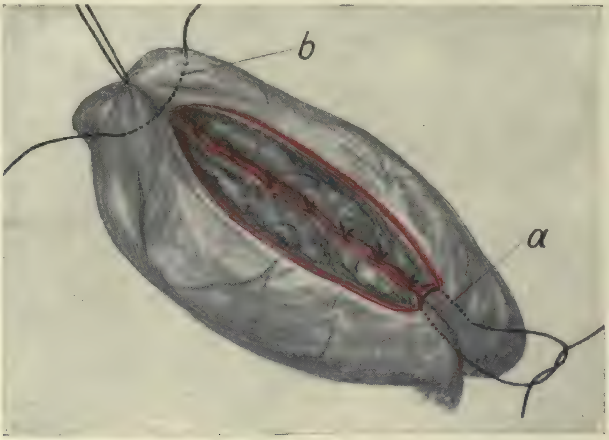


FIG. 312.—Lateral enteroanastomosis. II. Stage. The posterior row of sutures is now complete. At (*a*) introduction of the longitudinal end-stitch: at (*b*) introduction of the transverse end-stitch: this really belongs to the anterior row of sutures, and comes immediately after the longitudinal end-stitch.

The operator has now no difficulty in finishing off the anastomosis by introducing an anterior row of Lembert's (Fig. 314). The needle and

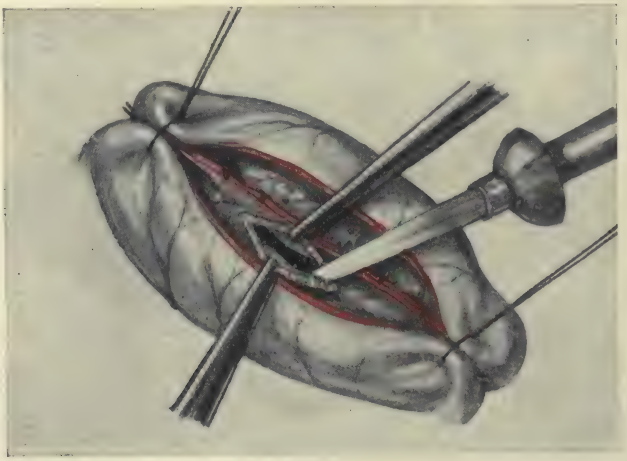


FIG. 313.—Lateral enteroanastomosis. III. Stage. The cross end-stitches have been left long after tying. The thermocautery is seen cutting through the mucosa into the lumen between forceps.

forceps are used in such a way that the cut edges are turned in by the stitches, serosa is made to lie against serosa and the mucous membrane disappears into the lumen of the bowel. After the last one has been introduced the surgeon cuts all the stitches short, takes off the clamps and carefully examines his handiwork once more, for there may be need ot one or two extra sutures; he should also test the size of the anastomosis with the finger tips.

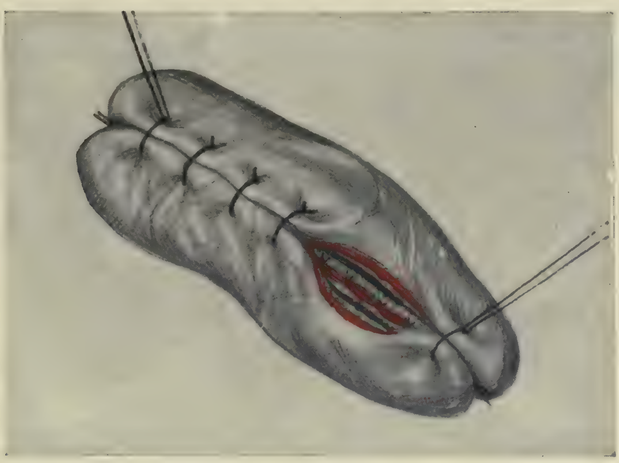


FIG. 314.—Lateral enteroanastomosis. IV. Stage. Introduction of the anterior row of Lembert's sutures after bilateral opening of the mucous membrane.

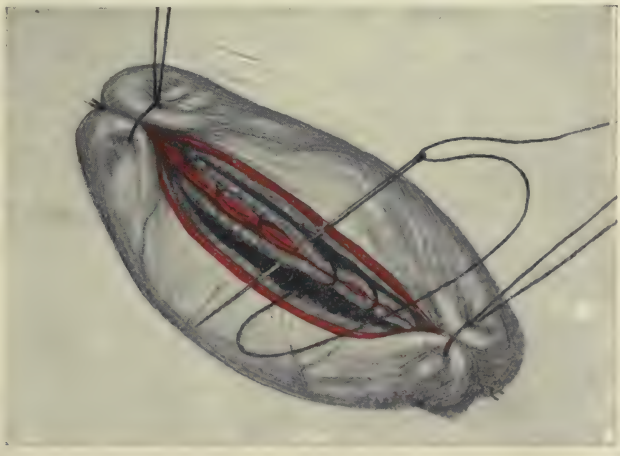


FIG. 315.—Lateral enteroanastomosis with the double suture. The two lumina have been opened by the thermocautery, and the posterior row of sutures and the end-stitches introduced. The edges of the mucous membranes are then united with a continuous stitch.

In Bier's clinic all gastric and intestinal sutures are introduced in this simple way, viz., as a single row. If you prefer the double-layer method of

Czerny, the lumen must be opened before the second inner row of sutures can be introduced. Fig. 315 illustrates the introduction of the posterior continuous suture into the mucosa.

If it has been resolved to use the double-layer method, it is advisable to make all the stitches continuous. The stitching can then be done very rapidly, and the stitches do not need to take such a broad grip of the seromuscular coat as in the single-layer method. The double-layer suture runs as follows (let us take enteroanastomosis as an example): Unite the two loops of gut with a continuous posterior serosa stitch (Fig. 316); then open the two pieces of gut $\frac{1}{5}$ in. ($\frac{1}{2}$ cm.) on each side of this initial stitch and run a continuous suture through the posterior mucous membrane, catching up all the three coats at one time (Fig. 317). Carry this suture on to the anterior wall opposite the first anterior suture, catching up all the coats and invaginating the mucosa as well as possible. This is secured by Schmieden's method of invagination suture. The needle is passed back and forward between the cut edges of the gut, being carried from inside to outside through all the three coats. Tie the end of this suture to the first stitch of the inner row, and then proceed to introduce an anterior layer of Lembert's; this should also be continuous and the very first suture may be utilized for the purpose.

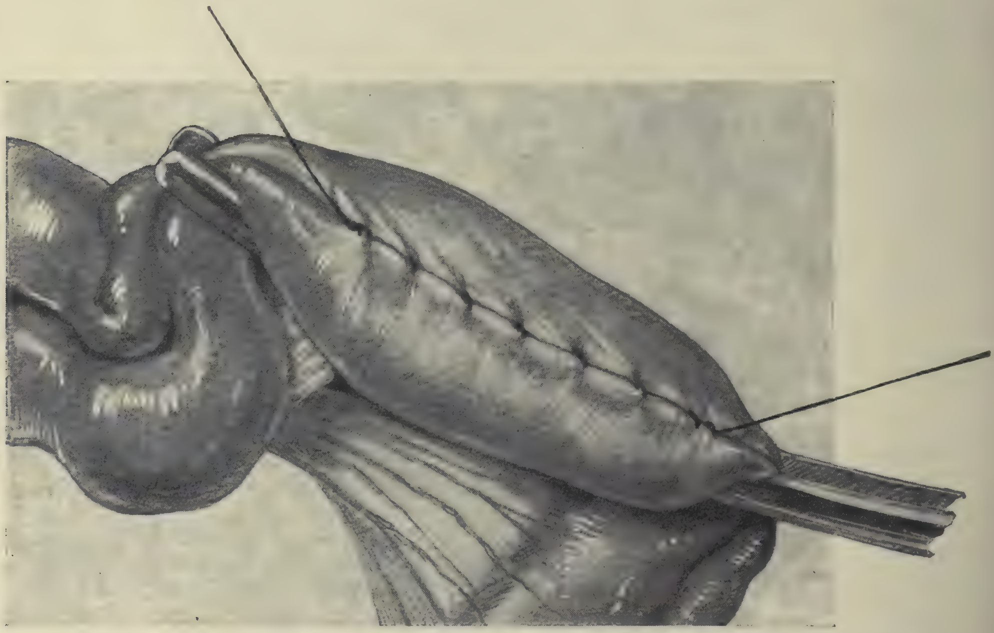


FIG. 316.—Anastomosis with double suture. I. Stage. Continuous posterior serosa stitch.

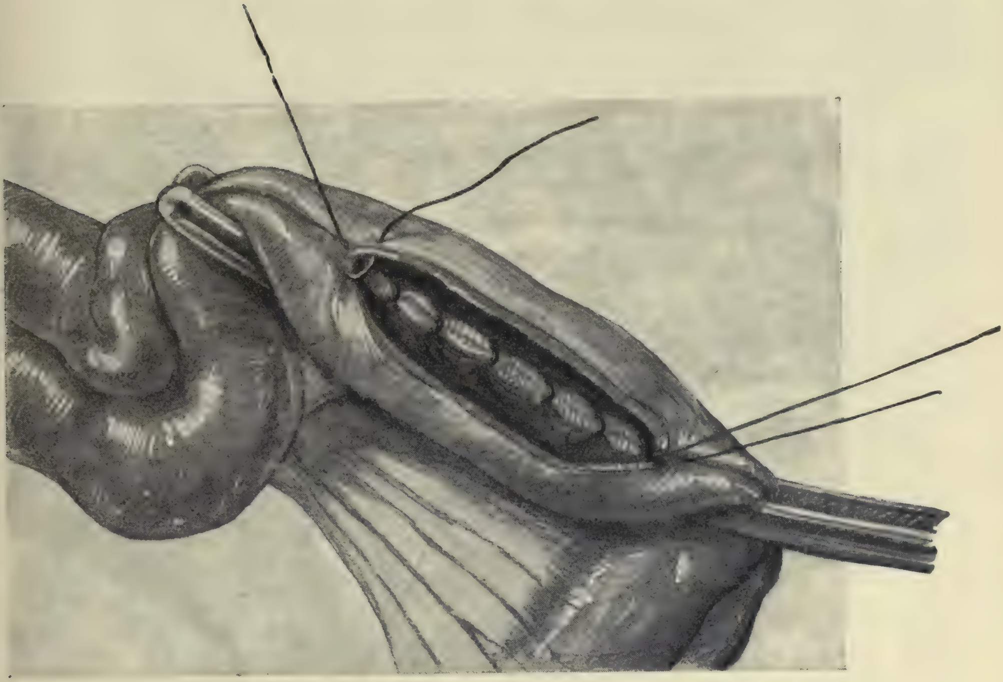


FIG. 317.—II. Stage. Continuous posterior mucosa stitch.

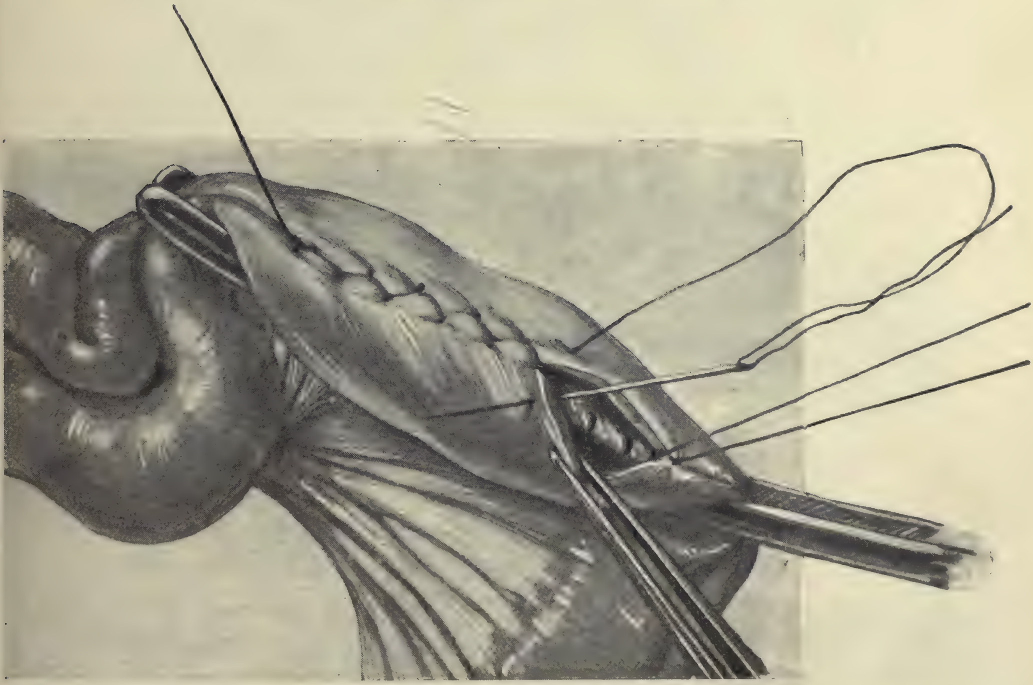


FIG. 318.—III. Stage. Continuous invaginating stitch through the anterior wall (Schmieden's method).

Fig 319 shows the result of the operation. The clamps can then be removed.

This important method of lateral anastomosis is performed between two parts of the stomach wall for the cure of hour-glass contraction; between stomach and small intestine in gastroenterostomy; between small intestine and small intestine in enteroanastomosis; between small intestine and large intestine in ileocolotomy; and, finally, between two coils of colon in colocolostomy. It is by far the most important piece of technique in the surgery of the abdomen.

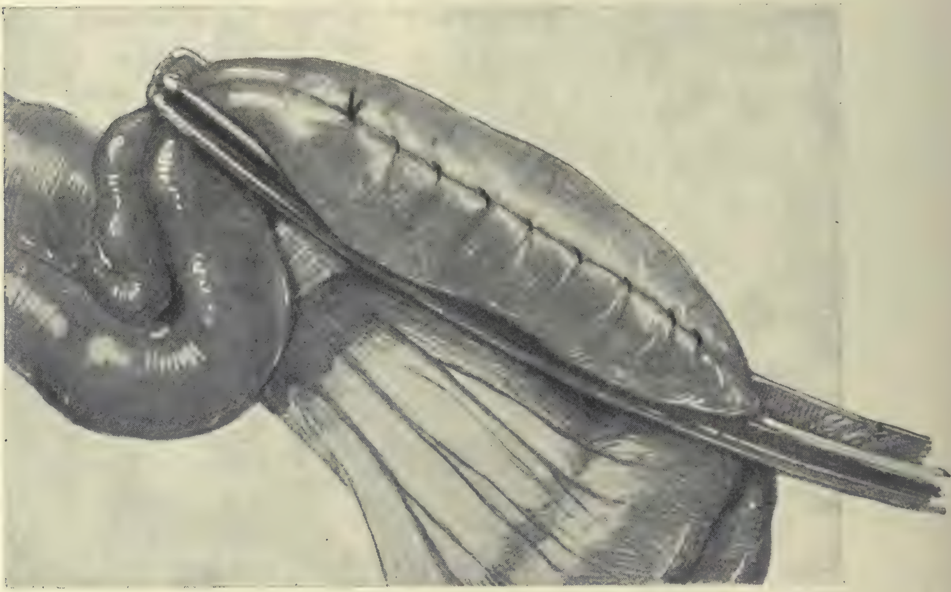


FIG. 319.—IV. Stage. Continuous anterior serosa stitch.

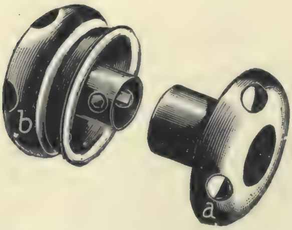
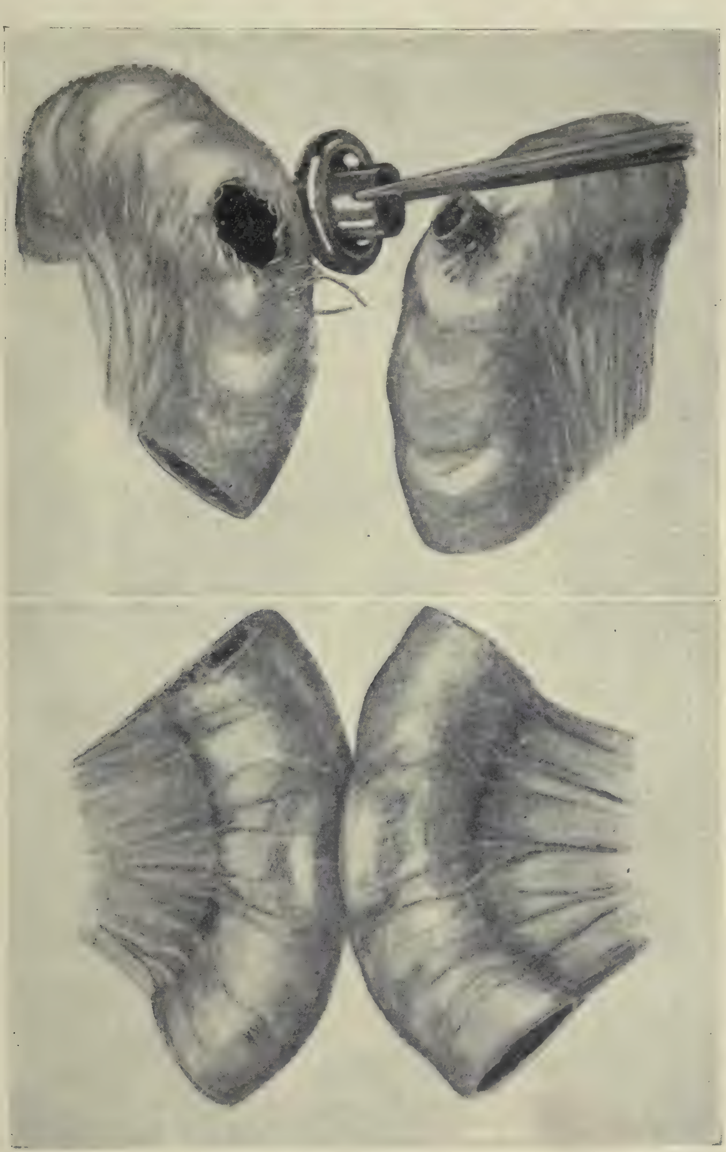


FIG. 320.—Murphy's intestinal button.

For rapid anastomosis Murphy's button is frequently employed. Nowadays it is reserved for cases where extra rapid technique is desirable: generally speaking, it has been abandoned in favour of suture. Although the technique of Murphy's button has been thoroughly evolved, it has not succeeded in displacing the various suture methods. The instrument consists of two halves which fit together: the so-called male half is the heavier and carries the spring (Fig. 320*b*). On pressing the two parts together they become securely fixed. Grasp each half with a Pean's forceps, and have them ready to hand. Begin by cutting an opening in one of the coils



Figs. 321 and 322.—The use of Murphy's button in lateral enteroanastomosis. Fig. 321, introduction of the two halves of the button ; Fig. 322, the union complete.

big enough to allow the button to pass through ; but before introducing it, run a purse-string suture round the mouth of the opening as shown in Fig. 321 ; then introduce one half of the button and tie the edges of the opening round its stalk. The same is done with the other half of the button to the other coil of bowel. Next press the two halves together, and the two rings will press the walls of the intestine against each other, serosa on serosa (cp. Figs. 321 and 322). If the technique has been successful no part of the mucous membrane should remain seen; if bits of the mucosa are still protruding, it will be necessary to add a few Lembert's sutures. The heavier half of the button must always be placed in the distal loop of gut, so that the instrument may drop in that direction. The button becomes free in about eight days by the sequestration of the crushed intestinal walls. By that time the anastomosis is firmly established.

Murphy's button can be used to connect the stomach to the small intestine in exactly the same way. It is not advisable to employ it in the case of the large intestine.

A. Operations on the Stomach.

1. *Gastrostomy.*

Gastrostomy is the establishing of a fistula into the stomach. It is carried out in oesophageal strictures to allow of the entrance of food into the stomach. The aim of operative technique is to find a method that will ensure a permanent fistula and at the same time prevent the outflow of food from the stomach. Various methods have been recommended: Witzel's gastric fistula is the one we shall here describe.

The incision is described above and illustrated in Fig. 276, No. 5. It is a linear cut through the left rectus, immediately below the costal margin: we nearly always strike the exposed anterior surface of the stomach. If the liver is found to have sunk somewhat downwards, its edge must be drawn up. If omentum is encountered, we must draw it downwards till the greater curvature of the stomach comes into view. The viscus is recognized by its size and smooth surface, as well as by the important vascular branches that arise from the epiploic vessels. We now seek the middle of the anterior stomach wall, choosing a spot that seems free of blood-vessels. We then draw a cone of the stomach wall out of the abdomen. Then take a rubber tube the size of a pencil and stitch it between two folds of the stomach wall, as shown in Fig. 323. Use Lembert's sutures and catch up only the serous and muscular coats; the stitches should draw two broad folds of stomach wall over the tube, and no gaps should be left between them. Then catch up the stomach at one end of the line of sutures with a pair of forceps, make a small opening and insert about 2 in. (5 cm.) of the tube into the interior of the stomach. Fasten the tube to the mucous membrane of the stomach with a single stitch of fine absorbable catgut. Then continue to raise the stomach wall in two folds and stitch them over the place where the tube perforates the mucous membrane: this is simply a continuation of the first line of sutures. The cone of the stomach is now replaced in the abdomen, and the operation completed by taking the stomach where the tube first meets it and stitching it all round to the edges of the peritoneum (*v.* Fig. 324). Finally suture the divided layers of the abdominal wall

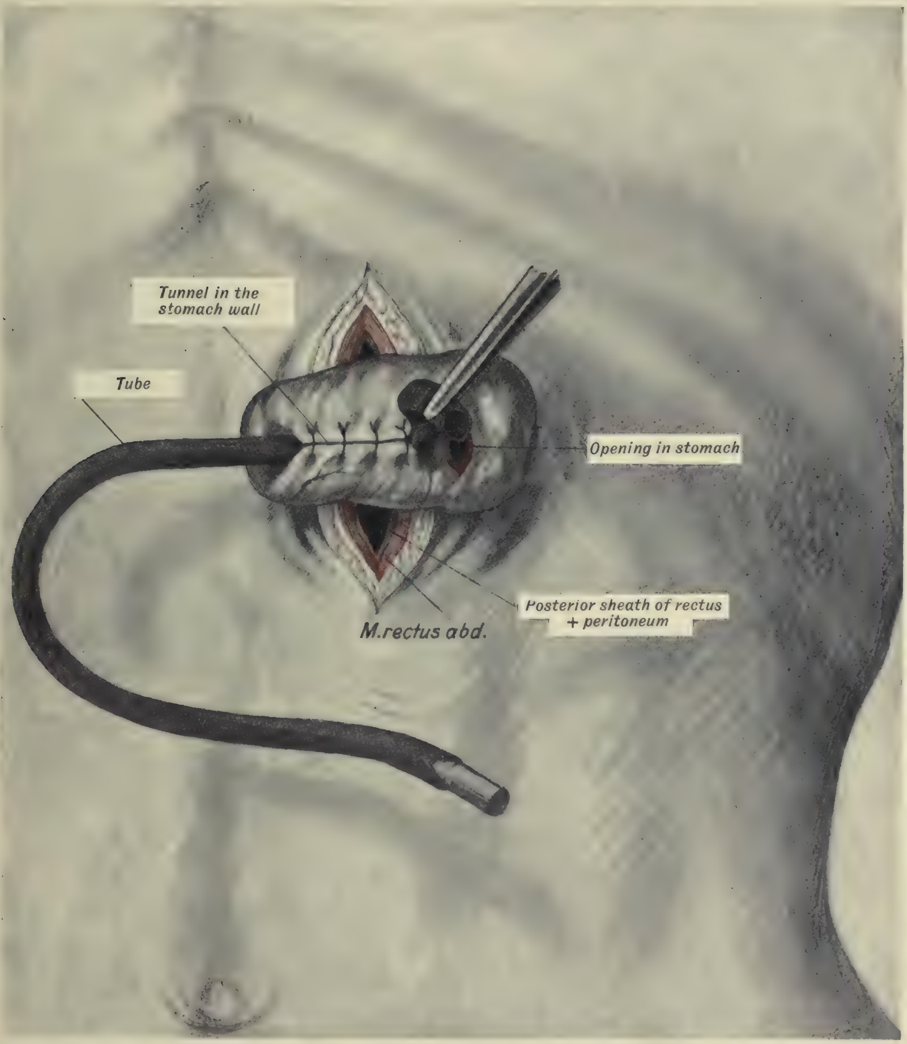

Tunnel in the stomach wall
Tube
Opening in stomach
Posterior sheath of rectus + peritoneum
M.rectus abd.

FIG. 323.—Witzel's gastrostomy. I. Stage A piece of the stomach has been drawn out, a tunnel formed, and the end of the tube is seen being introduced into a small opening in the stomach.

above and below the tube in the usual way, till eventually all that is seen is a rubber tube coming out through a small hole in the skin.

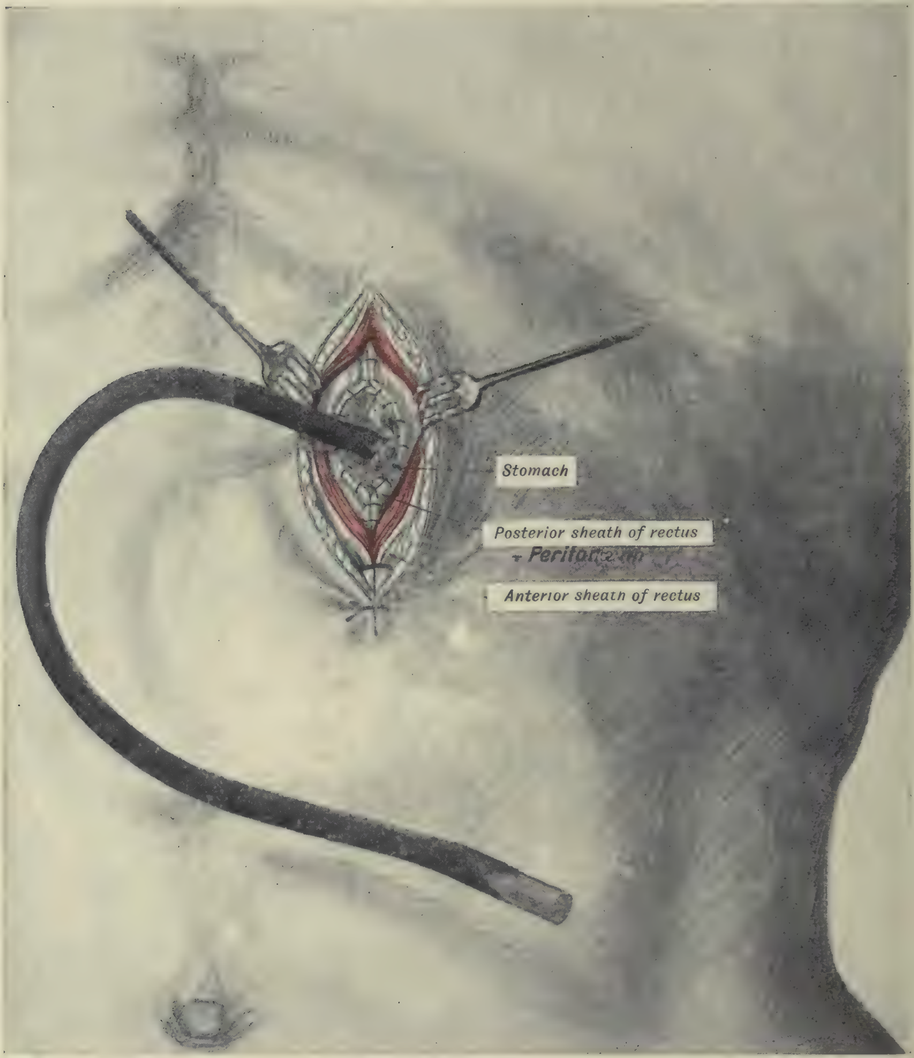


Fig. 324.—Witzel's gastrostomy. II. Stage. The peritoneum has been stitched all round the spot at which the tube enters the tunnel. Suture of the abdominal wall.

2. *Gastroenterostomy.*

To circumvent narrowing of the pylorus, an artificial connection can be made between the stomach and the small intestine; this method has been in vogue since the time of Wölfler. The original method was to anastomose a coil of the small intestine to the anterior wall of the stomach. It is not the purpose of this book to refer to the whole host of methods by which the original idea has been modified. The conditions for a successful operation are: (1) the opening must not become narrower or close up; (2) the food must be free to pass into the intestine. The greatest danger of faulty technique is the vicious circle, *i.e.* the entrance of food into the proximal loop of bowel and its regurgitation into the stomach. The diagram in Fig. 325 shows how the stomach contents get diverted by the so-called spur into the proximal loop of duodenum, which therefore becomes more and more distended. Unless a fresh operation is performed after this accident death will rapidly ensue. One way of meeting the difficulty is to bring the loop of small intestine into isoperistalsis with the stomach, by laying it against the anterior wall of the stomach in an oblique direction downwards and to the right: the anastomosis itself is placed as near as possible to the deepest point of the anterior curvature, while the small intestine is fixed up with a few stitches to the gastric serosa. This makes it impossible for the food to regurgitate (*v.* Fig. 326).

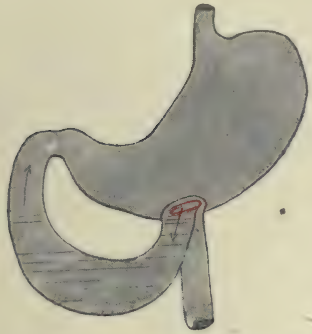


FIG. 325.—Gastroenterostomy with regurgitation of food into the duodenum (vicious circle).

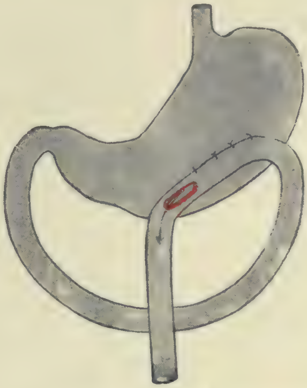


FIG. 326.—Anterior gastroenterostomy with isoperistaltic anastomosis and stitching up of the afferent end to the stomach.

There is always the possibility of the small intestine kinking at its highest point of fixation to the stomach; and this will interfere with the passage of the bile and pancreatic juices from the duodenum into the jejunum. The result is that the juices flow back through the pylorus (if it is still patent), enter the stomach and then find their way into the jejunum by way of the gastroenterostomy.

Braun and Roux have therefore devised improved methods. Braun, as shown in Fig. 327, does an enteroanastomosis in addition to the anterior gastroenterostomy: he thus prevents the vicious circle and permits the bile to escape. Roux attains a similar result by the method illustrated in Fig. 328: the operation while theoretically ideal is rather too extensive. The bowel is divided right through to the mesentery; the efferent end is then anastomosed into the wall of the stomach, while the afferent end is stitched into the side of the jejunum further down (Y method).

v. Hacker evolved quite a new method of gastroenterostomy. He connected the jejunum not to the anterior but to the posterior wall of the stomach by bringing it up behind the transverse colon. The diagram in Fig. 287 represents a sagittal section through the abdomen; it is evident from this that in doing an anterior gastroenterostomy we have to take a roundabout course over omentum and transverse colon before the two lumina can be brought into relation. We have therefore to go at least 16 in. (40 cm.) down from the duodeno-jejunal flexure in order to reach a long and freely movable part of the mesentery. In posterior gastroenterostomy it is quite different; in this case the uppermost loop of jejunum lies in close relation to the posterior wall of the stomach and an opening in the transverse mesocolon is all that is wanted to anastomose the uppermost piece of jejunum to the stomach: the middle colic artery runs in the transverse mesocolon and must be carefully preserved. After the operation the coils of intestine occupy their physiological position; moreover, only a small part of the bowel is excluded from alimentary circulation. The vicious circle is still a possibility, however, even in posterior gastroenterostomy, and there are a large number of methods planned to avoid this danger; let us mention in passing

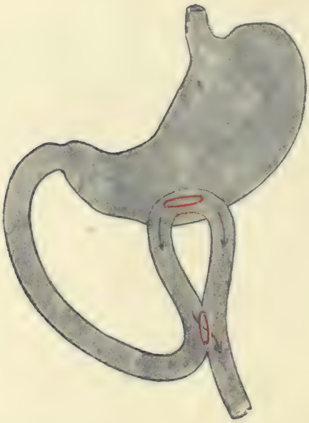


FIG. 327.—Anterior gastroenterostomy with subsequent enteroanastomosis (after Braun).

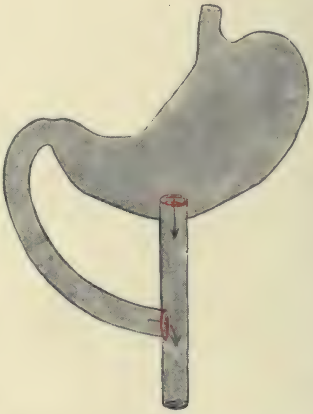


FIG. 328.—Anterior gastroenterostomy (Roux's Y-method).

that the excellent ideas of Braun and Roux can be practised with equal success in the case of posterior gastroenterostomy. A most serviceable piece of technique has been worked up by many surgeons, but more especially by Petersen; he pulls the loop of jejunum well forward and performs the anastomosis at its uppermost point. v. Hacker's idea of posterior gastroenterostomy has been brought to full fruition in the method known as Gastroenterostomia retrocolica posterior verticalis; it is described further on.

Which of these numerous methods and modifications is to be recommended, more especially for practice on the dead body? Every operator chooses the method that gives him the best results. Whatever the method, the application of it must be correct and uniform, and the operator must have every detail at his finger ends. In Bier's clinic we generally employ Gastroenterostomia retrocolica posterior verticalis; it is only when we are confronted with technical difficulties, *e.g.* when the disease affects the entire posterior wall of the stomach, that we do an anterior gastroenterostomy followed by enteroanastomosis. We shall now proceed to the description of these two methods.

(*a*) *Gastroenterostomia retrocolica posterior verticalis.*

The operator stands on the right side of the subject, and opens in the mid line of the abdomen between the ensiform process and the umbilicus (*v.* Incision 1 in Fig. 276). The anterior wall of the stomach usually comes into view at once, with the great omentum attached to its greater curvature. Draw the omentum out of the abdomen and throw it upwards; grasp it in the left hand and put it on the stretch so as to discover the underlying transverse colon; then grasp the transverse colon with the left thumb and draw it well forwards; next pass the right hand underneath the colon in order to locate the uppermost coil of the jejunum at the duodeno-jejunal fold with certainty and speed; this is an important bit of procedure and is carried out as follows:—having passed the right hand straight backwards palpate the vertebral column: here in the angle between the mesocolon and the column you can feel the lumpy substance of the pancreas: the uppermost coil of jejunum appears immediately below the pancreas. Grasp it and put it on the stretch: the part that is fixed to the mesocolon and cannot be drawn out may be regarded as the duodeno-jejunal flexure. Fig. 329 represents what is seen when the stomach, omentum and colon are thrown upwards. The operator now seizes the jejunum as far up as possible and catches up a longitudinal fold of the bowel with an intestinal clamp. Then grasping the colon and omentum with the finger and thumb of the left hand, he presses the stomach backwards against the mesocolon with the remaining fingers of the left hand, and dissects through an avascular part of the mesocolon : the posterior wall of the stomach now appears in the opening. In opening the transverse mesocolon, and in all the other manipulations, the middle colic artery must be preserved most carefully : it is represented in Fig. 329 ; if it is injured there

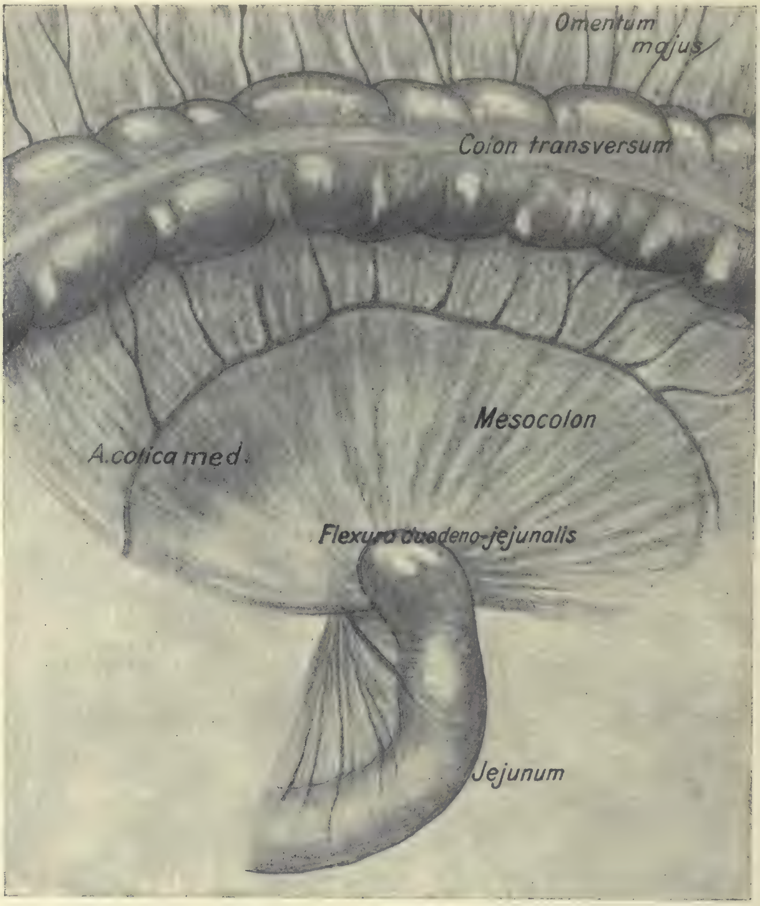


Fig. 329.—Posterior gastroenterostomy. I. Stage. Omentum and transverse colon are thrown upwards and the duodeno-jejunal flexure exposed.

is very grave risk of the transverse colon going gangrenous. The stomach is now lying with the greater curvature looking upwards and the lesser looking down. The dotted lines in Fig. 330 indicate how the anastomosis is made. A linear incision in the jejunum is stitched to a transverse incision in the stomach ; the transverse cut is made in the line of the gastric vessels, running at right angles to the deepest point on the greater curvature.[1] The incisions should be at least 2 in. (5 cm.) long. The point a in the jejunum should be stitched to the point a_1 in the stomach ; in order to manage this a large fold of the posterior stomach wall is caught up with

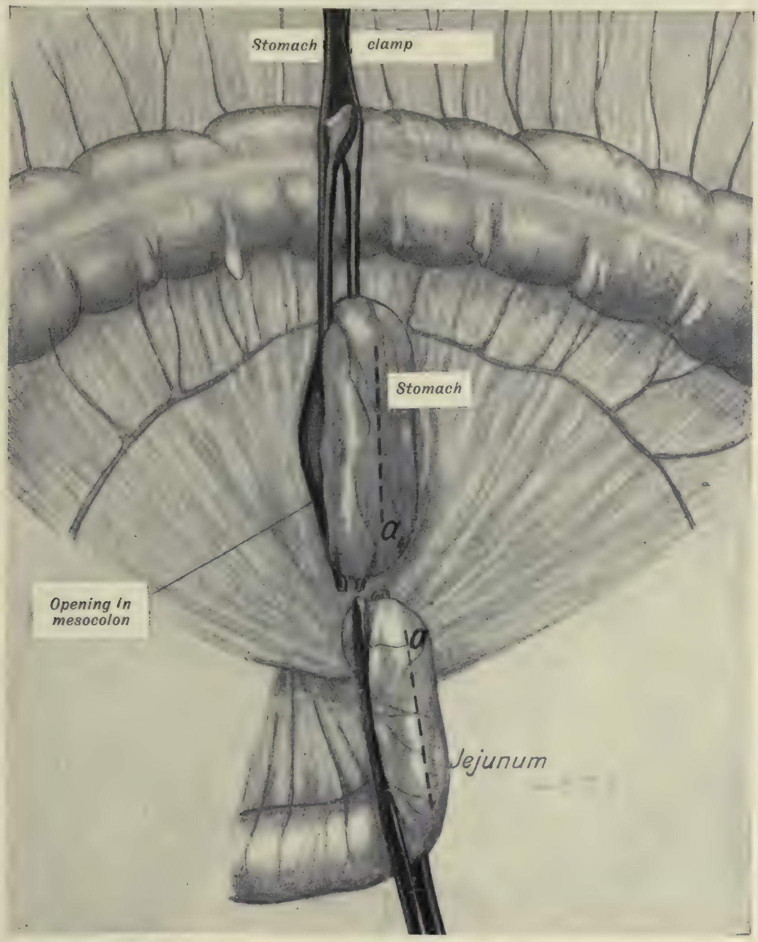


FIG. 330.—Posterior gastroenterostomy. II. Stage. The posterior wall of the mesocolon is drawn down through a slit in the mesentery and an oblique fold caught up with a clamp ; the uppermost coil of jejunum is caught up in its longitudinal axis.

a delicate intestinal clamp (*v.* Fig. 330), and the handles of the two clamps are laid parallel together (Fig. 331). The lateral anastomosis is carried out with a single layer of Lembert's, as in Figs. 311 to 314, or by means of the double-layer anastomosis (Figs. 316 to 319). Fig. 332 shows the final stage of posterior gastroenterostomy: the coil of intestine has been closely applied to the posterior wall of the stomach; the latter is then drawn up again through the opening in the mesocolon and is finally stitched into the opening by means of a few sutures; this shuts off the lesser sac of the peritoneum and prevents any other piece of bowel being caught in the opening. On the coils of intestine and the omentum being replaced, everything falls back into its original position; the anastomosed coil of jejunum leads directly downwards and an open passage is left for the food.[1]

---

[1] The incision in the jejumun is to be made close up to the duodeno-jejunal flexure. There is less unanimity in regard to the line of incising the stomach. Some surgeons ascribe the occurrence of a vicious circle to the incisions in stomach and intestine not lying parallel. They note that the usual direction of jejunum from the duodeno-jejunal flexure is downwards and *to the left*, *i.e.* the incision lies more or less transverse to the body axis ; they aver that if the stomach incision is made vertical a kinking of the

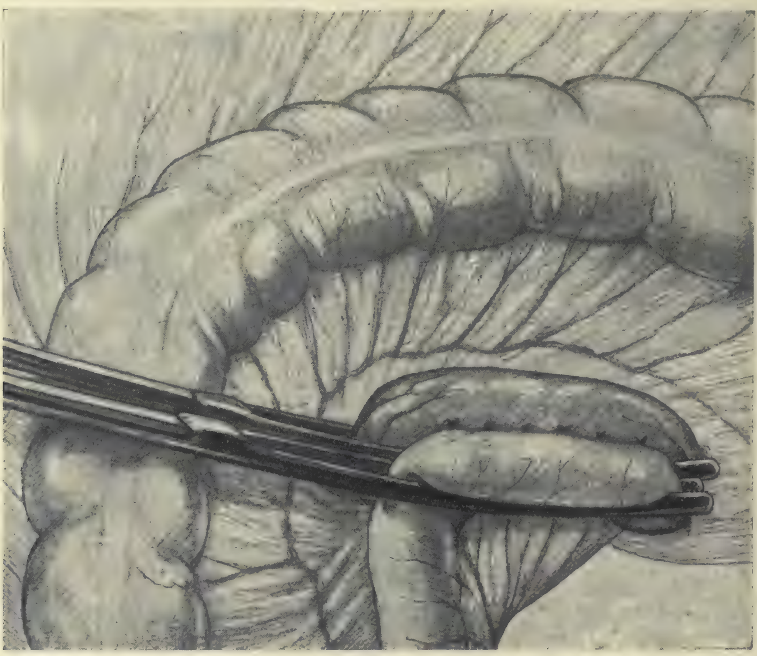


FIG. 331.—Posterior gastroenterostomy. III. Stage. The handles of the two clamps are laid parallel and the anastomosis performed, as shown in Figs. 311 to 319.

jejunum is apt to ensue; they hold therefore that the incision in the stomach should not be quite vertical (across the stomach), but should be placed more or less parallel to the axis of the stomach.

The general principles are :—

(1) Incise at the most dependent part of the stomach.

(2) Incise in each case to suit the position of the stomach and the direction taken by the jejunum.—TR.

[1] The opening into the duodenum may be occluded by means of an organic ligature, *i.e.* a strip of tissue cut from the rectus muscle and aponeurosis.—TR.

(*b*) *Gastroenterostomia antecolica anterior.*

The abdominal incision is the same as in the foregoing operation. The omentum and transverse colon are drawn out in the same way with the left hand, and the duodeno-jejunal flexure is sought with the right. Follow the jejunum down for at least 16 in. (40 cm) ; having thus secured a movable part, carry it round in front of the omentum and transverse colon and apply it to the anterior wall of the stomach. As shown in Fig. 333 the intestinal clamps are again used and a large lateral anastomosis made between the small bowel and the anterior stomach wall ; the usual silk sutures are employed, but a single interrupted layer of Lembert's is insufficient ; many large vessels are divided in incising the wall of the stomach, so it is preferable to employ Czerny's method of double-layer suture (bleeding being arrested when the mucosa is stitched separately).

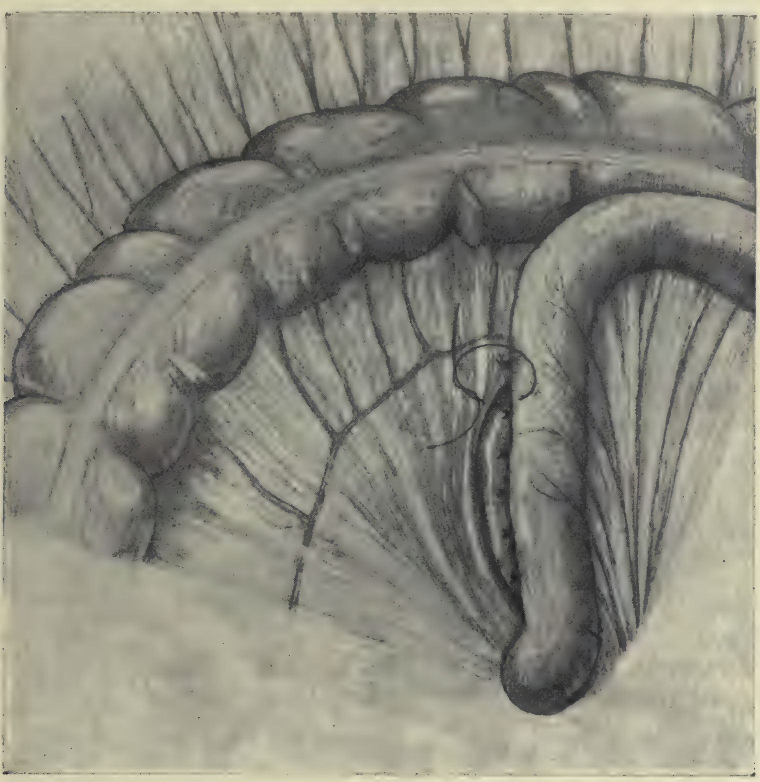


FIG. 332.—Posterior gastroenterostomy. IV. Stage. The gastroenterostomy is now complete ; the posterior wall of the stomach and the jejunum are stitched with a few sutures into the opening in the mesocolon.

A linear incision is made in the intestine : the incision in the stomach is also a longitudinal one and runs more or less parallel to the greater curvature. Fig. 333 shows how the gastroenterostomy operation is completed by an enteroanastomosis; this should not be made too close to the gastroenterostomy, it should lie below the level of the transverse colon, and the two limbs of the intestine between gastroenterostomy and enteroanastomosis should be of the same length. We must be sure that the operation does not lead to the transverse colon being too tightly gripped and constricted. The diagram also makes it clear that although a wide fistula is established between stomach and bowel (at least 2 in., 5 cm., in length), a 1-in. incision (2-3 cm.) is quite sufficient for the small enteroanastomosis (safety-valve anastomosis).

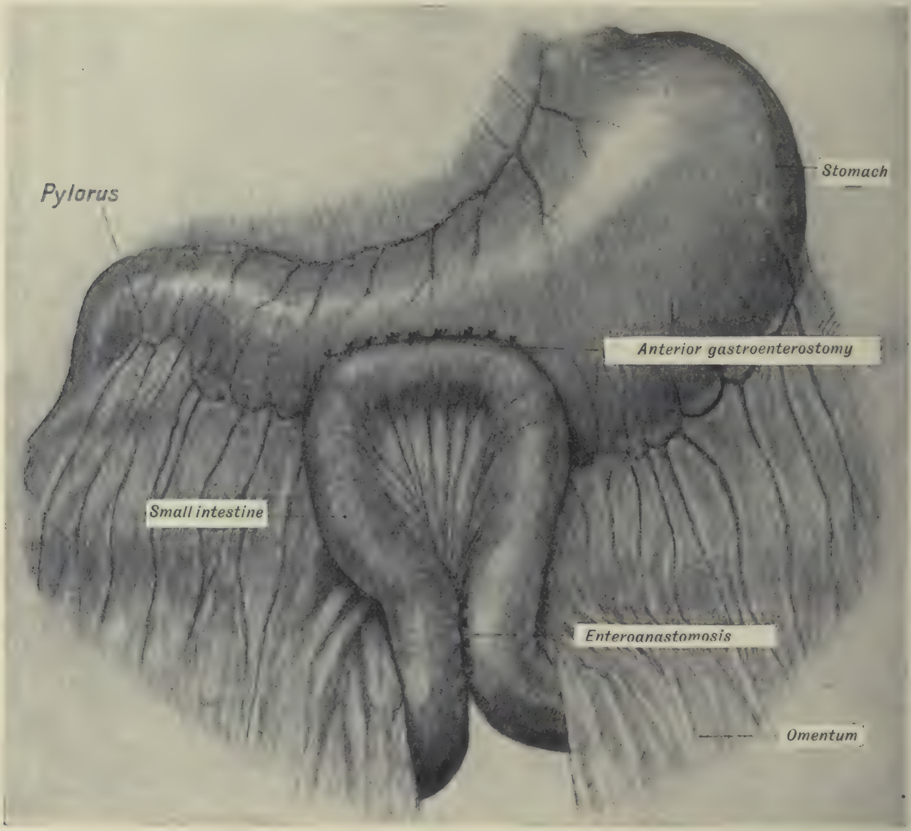


FIG. 333.—Anterior gastroenterostomy with subsequent enterostomy (after Braun).

Anterior gastroenterostomy is more easily accomplished than the posterior method. The latter can only be performed outside the abdomen if the stomach is movable; the former always. The beginner had better employ a large abdominal incision; the expert can manage everything through a small wound. On the dead body the beginner should use large incisions in order to learn the relations of the viscera.

3. *Pyloroplasty and Gastroduodenostomy.*

When we are dealing with a benign constriction of the pylorus it is not necessary to perform the relatively complicated operation of gastroenterostomy: in some selected cases we can try the simpler method of connecting the stomach with the directly adjacent duodenum. We can employ the pyloroplasty of v. Heinecke and v. Mikulicz. A linear cut is made in the anterior side of the pylorus; the incision runs a little way into both stomach and duodenum; it should be almost 3 in. (7 cm.) long (v. Fig. 334). The next figure (No. 335) shows how this linear incision is converted into a transverse opening by pulling the edges apart; Lembert's sutures are then introduced in such a way as to bring the corresponding points (x x) together. It is easy to understand how the passage becomes enlarged. Finney's operation is even better and more

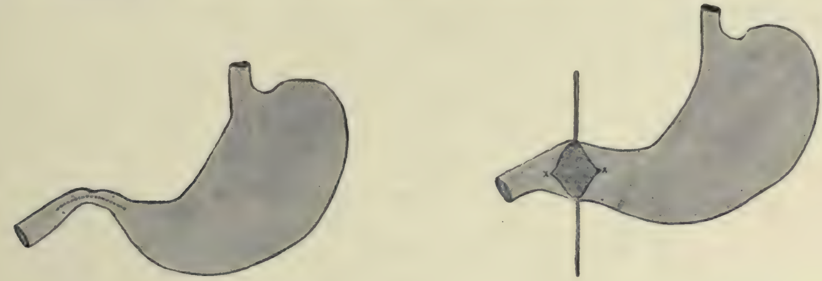


FIG. 334. FIG. 335.

Pyloroplasty in two stages (after v. Heineke and v. Mikulicz).

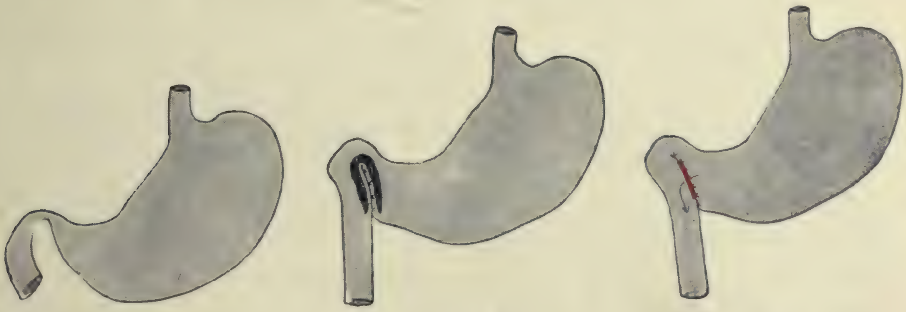


FIG. 336. FIG. 337. FIG. 338.

Gastroduodenostomy in three stages (after Finney).

thorough (Figs. 336 to 338). The stenosis is seen in Fig. 336; it is cured by stitching the stomach to the descending part of the duodenum on each side of the stenosis; a horseshoe incision is then made into stomach and duodenum, the posterior and anterior edges are united, and finally the original Lembert is carried round the anterior surface of the anastomosis. This is a simple way of curing a benign constriction of the pylorus: compare Fig. 338.

4. *Pylorectomy.*

The excision of the diseased pylorus is chiefly associated with the name of Billroth, for he was the first to carry out a successful operation of this kind and the technique has been carefully elaborated by him and his assistants. The two main methods are named after Billroth and are quite distinct from each other:

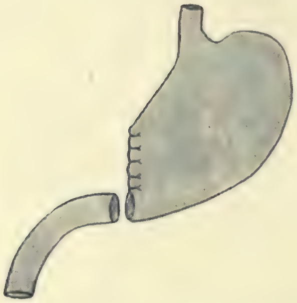


FIG. 339.—Excision of pylorus, Billroth I. method.

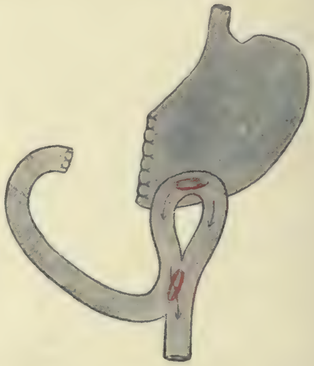


FIG. 340.—Excision of pylorus, Billroth II. method, with anterior gastroenterostomy and enteroanastomosis.

The Billroth I. method may be termed a pylorectomy followed by a circular anastomosis between stomach and duodenum; the Billroth II. method means the closure of the ends of stomach and duodenum and the establishment of an alimentary passage by subsequent gastroenterostomy. These are the two principal methods, but in addition there are a variety of useful and necessary modifications. Kocher's usual method is the most important of these, resection followed by posterior gastroduodenostomy (cp. Fig. 343). To give the reader a better idea of the methods described we have inserted the diagrams in Fig. 339 to Fig. 343. We have also included a plan showing the principal arteries of the stomach. The blood supply of this organ is very rich, arising from four large stems, two of which anastomose on the greater and two on the lesser curvature.

Along the greater curvature there runs the left gastro-epiploic artery, a branch of the splenic; the right gastro-epiploic is the corresponding artery on the right side; it comes off the gastro-duodenal branch of the hepatic, beginning at the pylorus and running forwards and to the left; the other branch is the superior pancreatico-duodenal which runs towards the duodenum. The coronary vessels on the lesser curvature of the stomach are the left and right coronary arteries, the former from the gastric, the

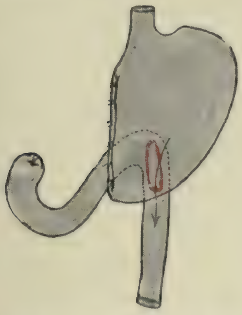


FIG. 341.—Excision of pylorus, Billroth II. method, with posterior gastroenterostomy.

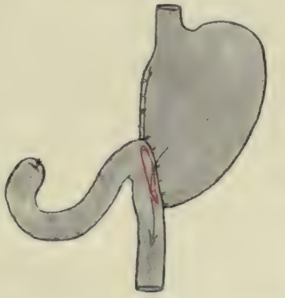


FIG. 342.—Excision of pylorus, Billroth II. method, with the uppermost coil of jejunum stitched to the lowest part of the stomach.

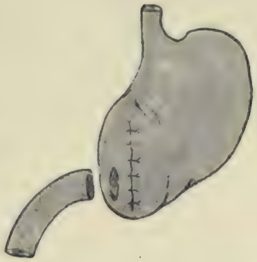


FIG. 343.—Excision of the pylorus, after Kocher.

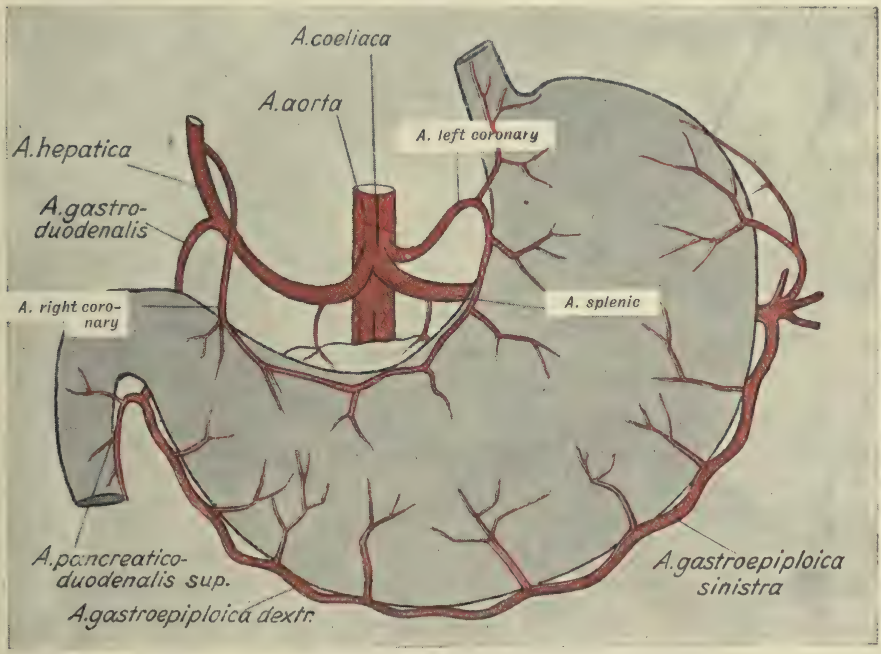


FIG. 344.—Diagram of the gastric arteries (after Gegenbaur).

latter from the hepatic artery. All four arteries are accompanied by veins and give numerous twigs to the anterior and posterior walls of the stomach (Fig. 344).

(*a*) *Pylorectomy : Billroth's I. method* (cp. Fig. 339).

The operator places himself on the right side of the table. He then makes a long median incision above the umbilicus, from the xiphisterum downwards ; in practising on the subject it is better to continue downwards beyond the umbilicus and thus secure a more complete view ; the round ligament of the liver is avoided by sweeping the cut round the left of the umbilicus. The pylorus is easily recognized, for the duodenum is of a grey-white colour and is sharply delimited from the stomach, which is yellowish-white ; the stomach is rosy-white in the living subject ; the pylorus is marked by a slight constriction and by a fairly large vein that runs under the serosa transversely to the axis of the gut. When the surgeon attempts to lift out the pylorus, the gastro-colic omentum is put on the stretch ; it hangs downwards and prevents him from grasping the stomach ; in an upward direction the gastro-hepatic and hepato-duodenal omentum is put on the stretch, this being the band that supports the stomach and

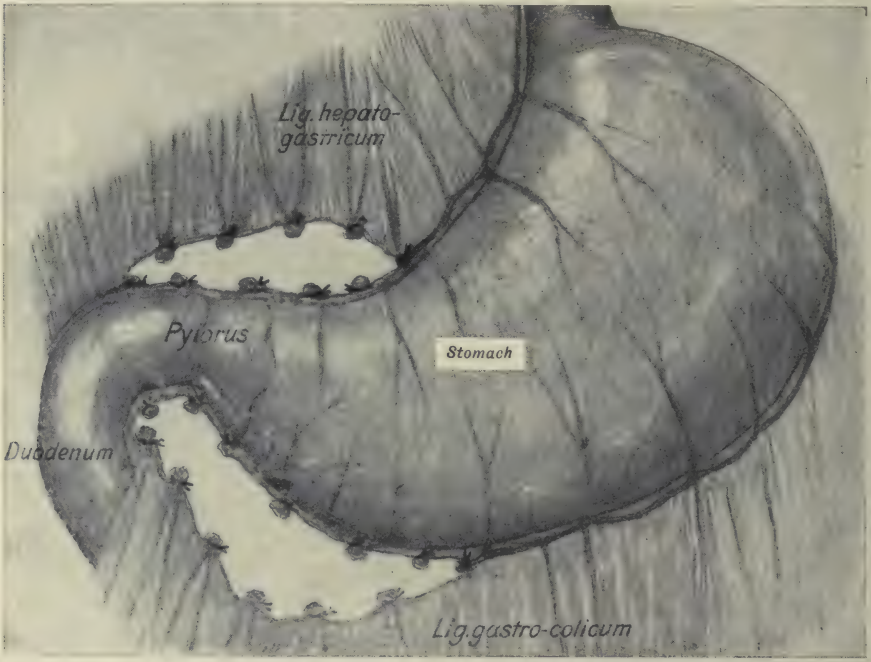


FIG. 345.—Resection of the pylorus after Billroth I. I. Stage. The gastro-colic and gastro-hepatic (+ hepato-duodenal) omenta are ligatured off and divided.

duodenum. Commence by freeing the gastro-colic omentum; it should be caught up in separate portions with an aneurism needle, ligatured off and divided. The gastro-colic omentum is sometimes firmly soldered to the transverse mesocolon; there is thus a risk of catching up the middle colic artery (supplying the transverse colon) on one of the ligatures; the gastro-colic omentum should therefore be divided close to the stomach, above the middle colic but below the gastro-epiploic artery. The stomach is to be separated in the whole extent of the part to be resected. The left gastro-epiploic artery and the pancreatico-duodenal artery should be isolated at each end on the left and right sides respectively, doubly ligatured and divided. Ligature off the gastro-hepatic omentum with the vessels contained in it exactly in the same way, and we are now in a position to resect the pylorus, which has been isolated as shown in Fig. 345.

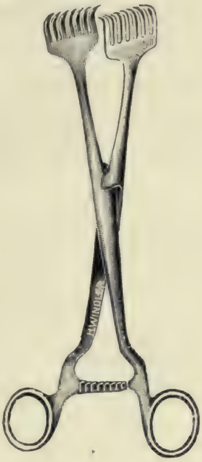


FIG. 346.—Toothed forceps (Muzeux).

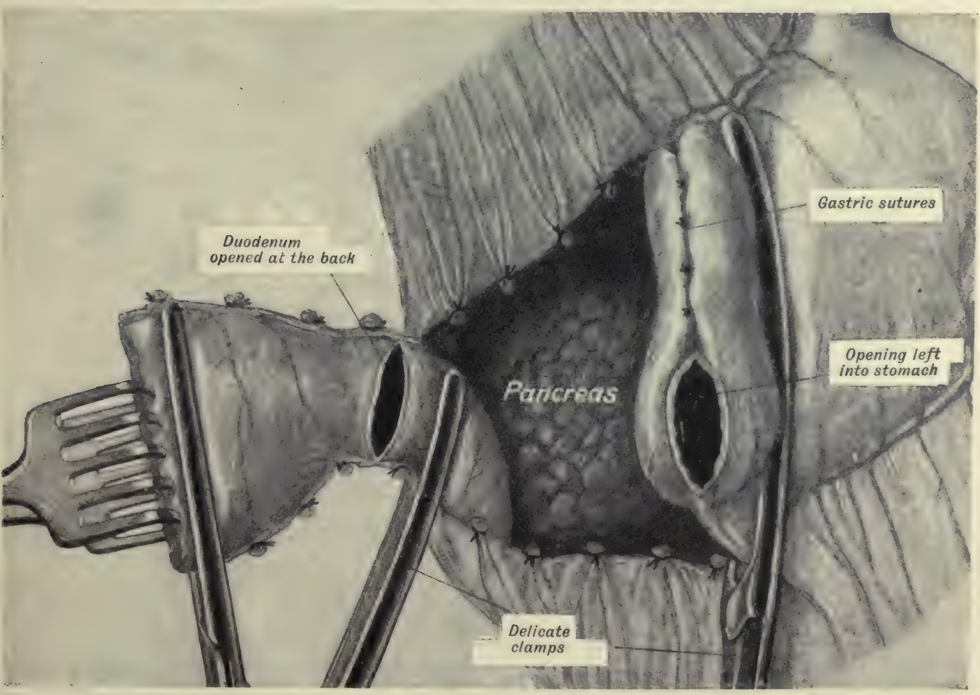


FIG. 347.—Resection of the pylorus, Billroth I. method. II. Stage. The stomach is divided, and the pyloric portion thrown over to the right. The large opening in the stomach is partially closed with Lembert's sutures and partially left open. The posterior wall of the duodenum is opened.

Up to this point of the resection the stomach has not yet been opened; we now proceed to open it. Begin by applying a delicate clamp across the stomach above the isolated portion and another further down in the isolated part itself, and then divide the stomach between the two clamps with straight scissors or burn it through with the Paquelin cautery. This transverse division should not be made too close to the upper clamp, or there will not be enough room for the invaginating suture. Having thus divided the stomach we throw the entire pyloric part over to the right, cover the free end with a compress and apply a large pair of toothed forceps (Muzeux's, Fig. 346). The forceps should be heavy, so as to draw the pylorus well out of the wound. Between the two halves of the stomach we can now see the pancreas and the posterior surface of the pylorus and first part of the duodenum. The main opening of the stomach in front of the clamp should next be closed in its upper half with a Lembert's stitch; the large blood vessels in the gastric mucous membrane may first be closed with an independent mucous stitch The stomach is not sutured up completely, but a part is left open with a diameter equal to that of the duodenum; the openings in stomach and duodenum are brought together afterwards. Fig. 347 shows this stage of the operation after the invagination suture has been introduced into the stomach. It also shows the duodenum opened from the back; the bowel is divided with a sharp knife distal to the pylorus and distal to the seat of the disease; at first only the posterior circumference is divided; if the separation is not sufficient

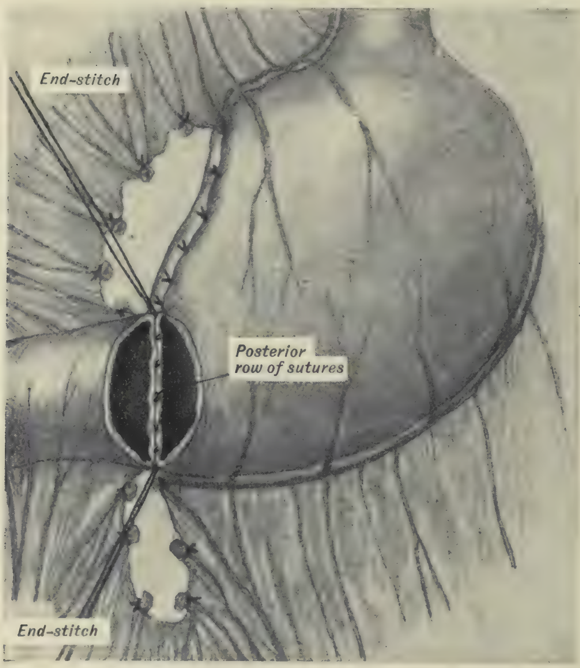


FIG. 348.—Resection of the pylorus, Billroth I. method. III. Stage. A posterior row of sutures has been introduced and the end-stitches left long; the resection of the diseased portion is completed by the division of the anterior wall of the duodenum, after which the anterior row of sutures may be inserted.

it should be continued until a delicate clamp can be applied. The anterior wall of the duodenum is not severed from the pylorus but is used as a means of completing the posterior suture. This posterior suture is carried out next. The openings in stomach and duodenum are brought into careful apposition and a row of Lembert's inserted; the upper and lower sutures are left long. The anterior part of the duodenum is then divided with the scissors and the resected pylorus removed. This stage of the operation is shown in Fig. 348. The circular anastomosis is completed by an anterior row of Lembert's sutures inserted in the usual way. These stitches require great care, especially where the upper stomach suture meets the circular one; all the stitches should be done slowly and correctly, so as to prevent constriction occurring at the point of suture. This completes the essential steps in the Billroth I. resection; the large opening in the gastro-colic omentum is closed with a few stitches, and the ends of the ligaments supporting the stomach and duodenum are carefully stitched to the upper line of sutures (*v.* Fig 349).

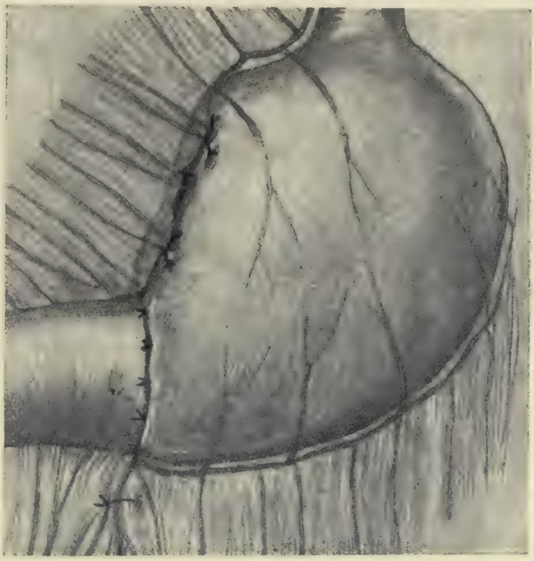


FIG. 349.—Excision of the pylorus, Billroth I. method. IV. Stage. The anastomosis is now complete; the gastro-hepatic omentum is restitched to the stomach, and the opening in the gastro-colic omentum closed.

(*b*) *Resection of the stomach according to Kocher* (Fig 343).

This begins in a similar way; the stomach is isolated and divided in the above manner; the only difference is that Kocher uses very powerful clamps (Fig. 350) so as to crush the viscus at the line of resection; it is divided immediately along the line of resection. Graser advises a special crushing clamp for the same purpose; the blades are split so that straight needles can be passed through and the opening stitched up (Fig. 351). Kocher now proceeds to close the large opening in the stomach by invaginating it with serosa sutures. The stomach is then turned over to bring the posterior surface into view; an opening is then made in the stomach a thumb's-breadth from the line of sutures; this should lie near the greater curvature and at right angles to it and corresponds to the transverse opening in the duodenum ; a circular (side-to-end) anastomosis is then performed between the end of the duodenum and the posterior wall of the stomach (*i.e.* pylorectomy followed by gastroduodenostomy) (Fig. 343).

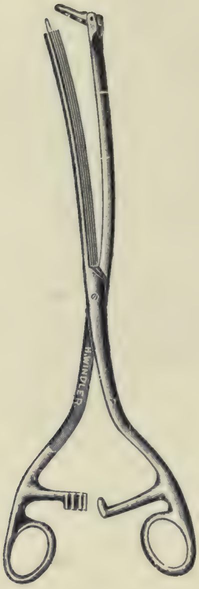


FIG. 350.—Kocher's stomach-crushing clamp.

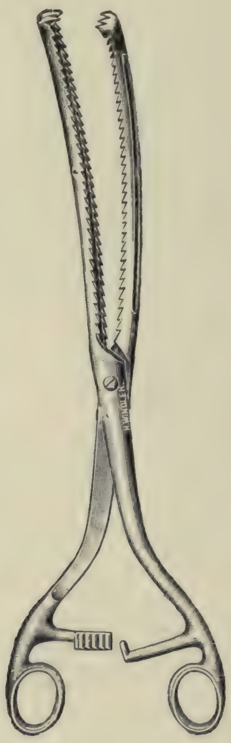
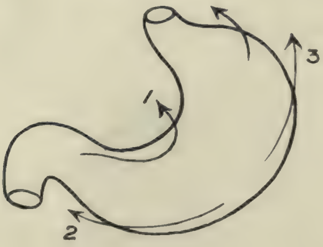


FIG. 351.—Graser's stomach-crushing clamp.

(*c*) *Resection of the stomach according to Billroth II. method* (Figs. 340–342).

The Billroth I. method is reserved for small pyloric cancers. The Billroth II. method is best employed in more extensive resections of the stomach. It is eminently suitable for cases where the line of resection has to run well up the lesser curvature, *i.e.* up to near the cardia It is usually possible to retain the upper half of the greater curvature.[1] In large resections of



1. To superior gastric nodes.
2. To inferior gastric nodes.
3. To splenic nodes.

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[1] This figure (after Polya and Navratil) illustrates how the lymphatics of the greater curvature resolve into two divergent streams, one running to the right and the other to the left.—TR.

this type a direct anastomosis of the divided ends might easily lead to excessive tension, so Kocher in the method above described recommends the mobilization of the duodenal stump. The Billroth II. method is frequently practised and is carried out in Bier's clinic as follows :—Begin by freeing the diseased part of the stomach from the gastro-hepatic and gastro-colic omenta in the usual way. The separation is effected by doubly ligaturing and dividing the omenta, but more of the stomach should be freed than is shown in Fig. 345. Suitable clamps are then applied and the diseased parts severed from the upper healthy part of the stomach ; the diseased portion is wrapped in gauze and is drawn out of the abdomen to the right. The large opening in the stomach is now closed, but so as to leave a considerable opening below (Fig. 352) ; the best way to effect this is by a continuous stitch and a superimposed row of interrupted Lembert's. A stout ligature is then passed round the duodenum on the distal side of the disease, the duodenum is divided, the diseased part is removed and the duodenal stump securely invaginated by means of a couple of Doyen's purse-string sutures. Two stages of the operation are shown in Figs. 352 and 353. Careful closure of the duodenal stump is of prime importance ; if it is not done carefully the stump re-opens under stress of the duodenal contents and a fatal peritonitis is the result. As shown in Fig. 352 the stump has first to be ligatured and then encircled with a wide purse-string suture ; the operator slowly tightens the suture while the assistant pushes the stump well in with dissection forceps. It is often possible to introduce a second purse-string suture, but if this cannot be managed take a piece of omentum, draw it over the invaginated area and stitch it in place. One may even include

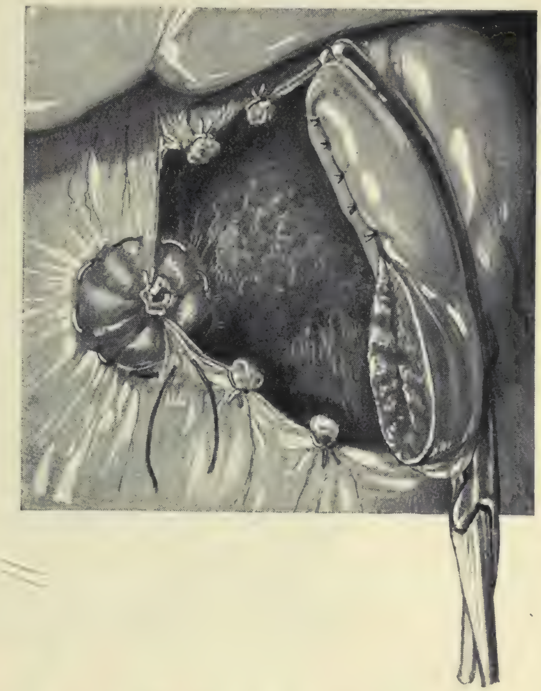

FIG. 352.—Resection of the pylorus, Billroth II. I. Stage. The part to be resected has been removed, as shown in Fig. 345. The half of the opening in the stomach is then closed, and the end of the duodenum closed with a Doyen's purse-string suture.

the capsule of the pancreas in the suture, but be careful not to pass the needle deep into the substance of the gland.

The surgeon now proceeds to the final stage of the operation—the gastroenterostomy. Make an opening in the transverse mesocolon according to the rules given for gastroenterostomy (Fig. 330), seize the highest coil of the jejunum, draw it through the opening and coapt it to the upper end of the stomach (Fig. 353). It is really better to bring up the coil of gut a good deal earlier, immediately after ligaturing off the omenta—the reason being that there is a risk of sepsis as soon as the stomach is opened; the jejunal coil can be caught up with a serosa stitch so that it is ready for manipulation at any moment. A linear incision is next made in the jejunum

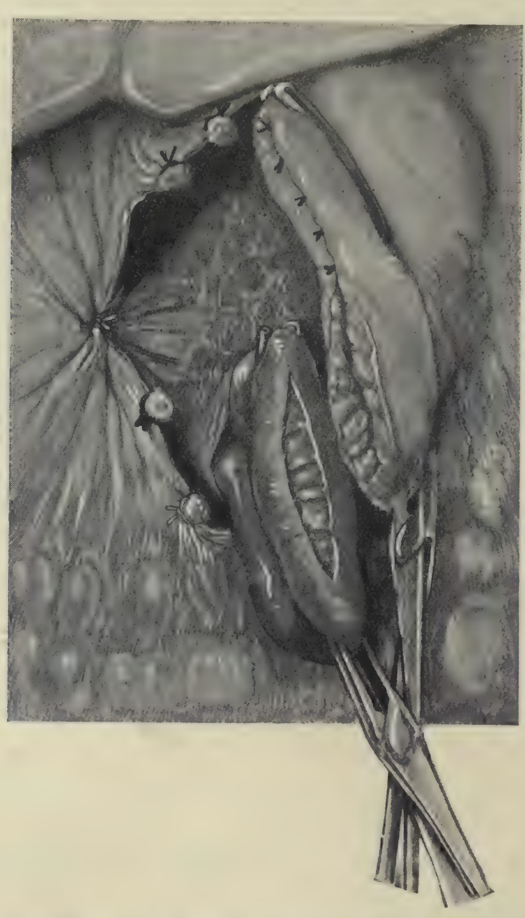

FIG. 353.—II. Stage. The end of the duodenum is then buried. An opening is made in the transverse mesocolon and the uppermost coil of jejunum drawn up and made ready for anastomosis with the stomach.

and the opening in the stomach is then united to that of the intestine by end-to-side anastomosis (*v.* Fig. 353). Always see that the afferent loop of intestine lies above and the efferent loop below. The clamps are now removed and the site of the gastroenterostomy stitched to the opening in the mesocolon in the usual way (Fig. 354). This completes the resection. A large opening is now left between the ends of the gastro-hepatic and gastro-colic ligaments, and this should be stitched up with a few sutures.

This method of gastroenterostomy that has just been described and illustrated can be modified in a variety of ways. For instance, the upper gastric portion may be completely closed, and a typical anterior or posterior gastroenterostomy carried out (*v.* the diagrams in Figs. 340 and 341). Finally, many operators prefer to start with the posterior gastroenterostomy and then proceed with the resection of the pylorus and the end-closure of the stomach and duodenum.

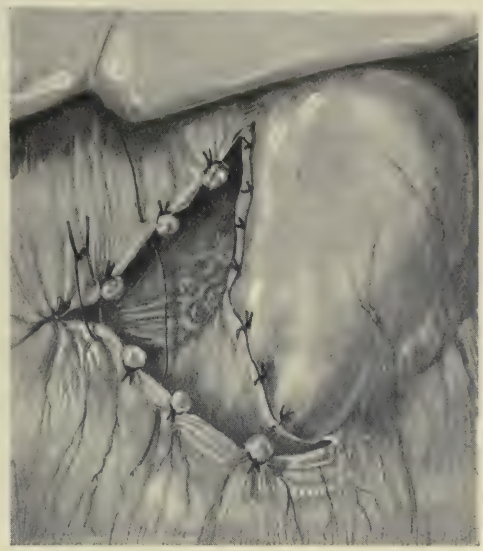

FIG. 354.—III. Stage. The jejunum is next anastomosed to the opening in the stomach. The bowel is then withdrawn through the mesocolon and the free edges of the latter stitched round the stomach.

B. OPERATIONS ON THE INTESTINE.

1. *Jejunostomy.*

The aim of this operation is to establish an alimentary fistula below the stomach in cases where it is impossible to make a gastric fistula. It is just as important here as in the stomach for the food to run in easily and not to regurgitate.

There are three methods by which this can be attained.

1. v. Eiselsberg's.—Open the abdomen and draw out the uppermost coil of jejunum; the way to expose it is described above in gastroenterostomy. Introduce a tube into the bowel about 12 in. down from the duodeno-jejunal flexure, employing Witzel's oblique method (described in connection with the formation of a gastric

fistula and figured in Figs. 323 and 324). The end of the tube should always lie in the direction of the efferent coil of bowel. The peritoneum is stitched round the site of the fistula exactly as in gastric fistula, and the abdominal wall is closed tightly round the tube.

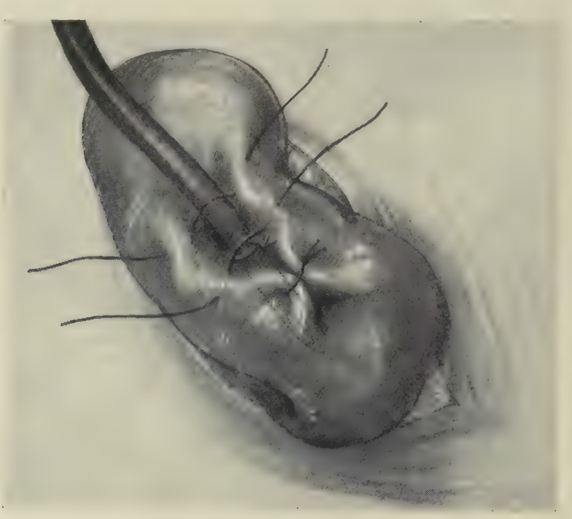

FIG. 355 —v. Eiselsberg's jejunostomy. Formation of an oblique canal.

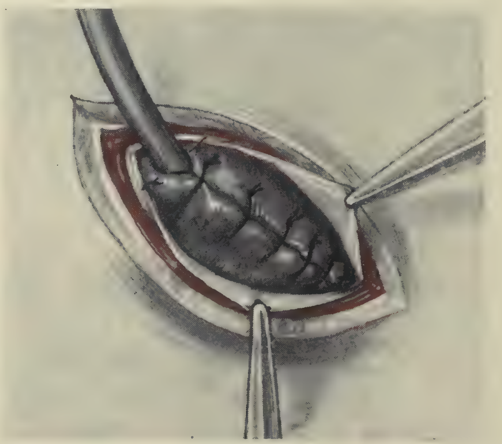

FIG. 356.- v. Eiselsberg's jejunostomy. Stitching to the parietal peritoneum.

v. Eiselsberg's method is shown in two stages in Figs. 355 and 356.

2. Mayo-Robson draws the same coil of jejunum out of the abdominal wound and then performs a wide anastomosis on the two limbs of

bowel. The coil is then replaced and its summit sutured into the abdominal wall. It is opened in a few days and a rubber tube introduced for feeding purposes (*v.* the diagram in Fig. 357).

3. Maydl in performing jejunostomy employs Roux's principle of Y-shaped anastomosis (Fig. 358). The bowel is cut across some 12 in. (30 cm.) below the duodeno-jejunal flexure; the mesentery is then extensively divided and the upper end anastomosed into the gut some 8 in. (20 cm.) further down (end-to-side anastomosis). Another small opening is made in the abdomen near the first incision and in the centre of the rectus muscle, and the lower end of the gut is drawn out and stitched firmly into the skin or carried obliquely through the abdominal wall in order to secure efficient closure, as indicated in Fig. 358. The original laparotomy wound is closed completely.

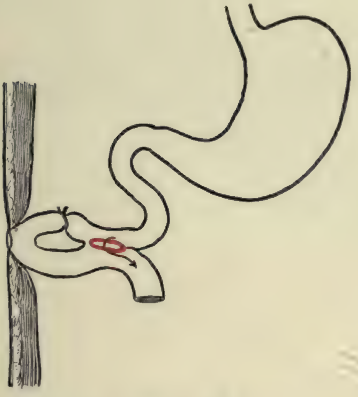

Fig. 357.—Mayo-Robson's method of jejunostomy.

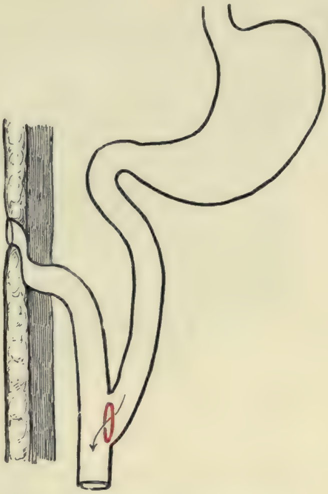

Fig. 358.—Maydl's method of jejunostomy.

2. *Resection of the Small Intestine.*

This operation is of prime importance and its technique is not difficult. The small intestine is exposed and the part to be resected is drawn well out and supported on compresses. We then decide the amount of resection and the method of anastomosis to be finally adopted.

(*a*) *Resection followed by circular anastomosis* (*end-to-end union*).

Empty the bowel by stripping out the contents towards the two sides and apply a light clamp above and below. Begin by separating away the mesentery. This is done step by step, clamping off and ligaturing as we go; the best way is to introduce the ligature on a Deschamp's aneurism needle backed by a blunt Kocher's thyroid sound, as shown in Fig. 359. The separation of the mesentery is effected at its intestinal attachment (cp. Fig. 359). This rule, however, is not observed when extensive resections have to be undertaken; the mesentery has then to be resected obliquely as shown in Fig. 360. The mesentery must never be separated close up to the bowel when we are dealing with a malignant affection; the indication then is to remove a wedge-shaped piece of mesentery together with the diseased lymph glands. It often becomes difficult in these cases to determine whether the ends of gut are properly nourished or not, and the only way to settle the question is by carefully inspecting the divided ends. Fig. 361 shows the mesentery almost completely separated from the intestine; a pair of clamps is then applied to the gut on either side of the isolated portion, and the bowel divided with a pair of straight scissors at the two points of intended resection; this division should not be exactly at right angles to the axis of the gut, but somewhat obliquely, as shown in Fig. 361, rather more being excised from the side opposite the mesentery; in this way the ends and their cut surfaces remain well supplied with blood and there is less likelihood of constriction resulting from circular anastomosis.

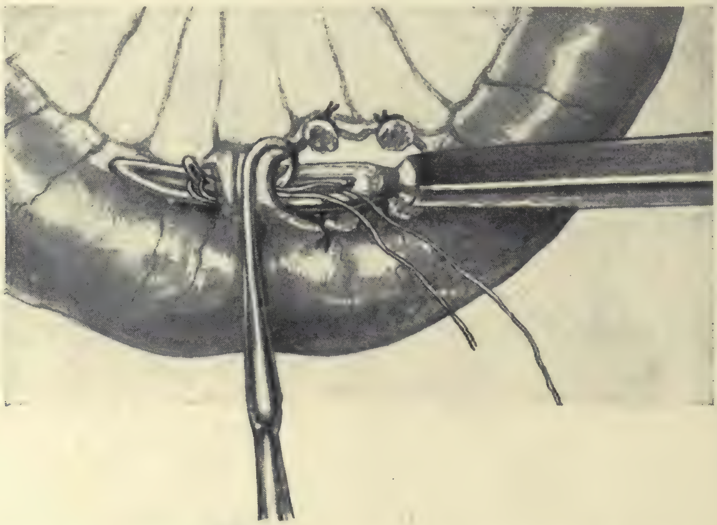

FIG. 359.—Ligature and division of the mesentery prior to resection of the gut.

As soon as the piece of bowel has been excised we proceed to unite the cut edges; Bier uses a single Lembert's suture only. Begin by coapting the two ends. The two first sutures should then be introduced close to the mesenteric attachment and are left long. These sutures are the most

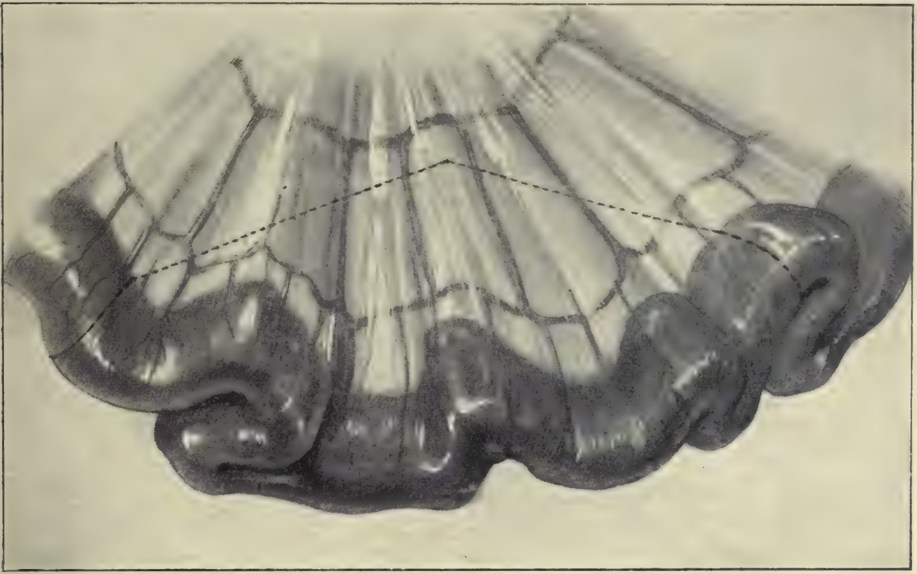

FIG. 360.—Line of resection through the mesentery in extensive resection of the gut.

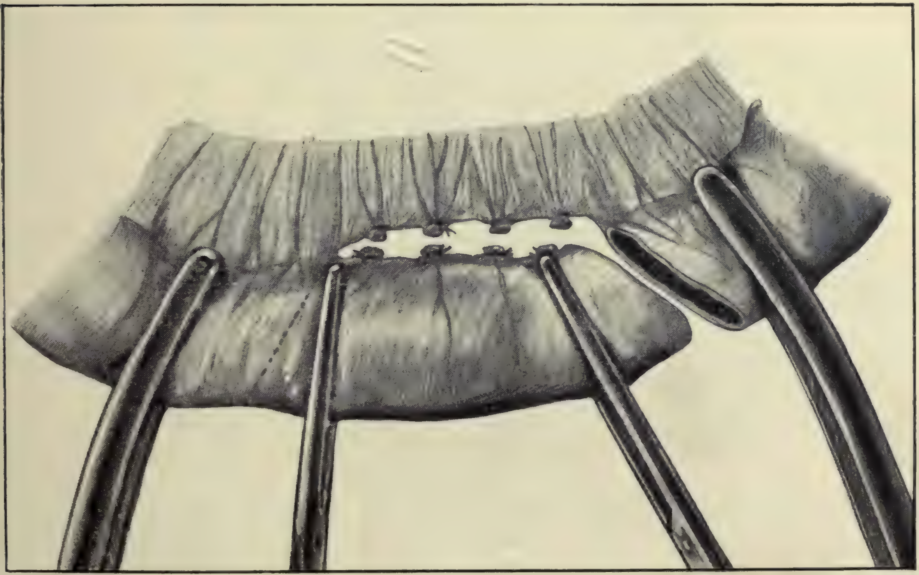

FIG. 361.—Resection of the small intestine. I. Stage. The intestinal clamps are applied and the mesentery ligatured off and divided. The division of the intestine is made obliquely.

difficult ones to introduce, for they have to lie absolutely correct. Fig. 362 shows the way they are inserted. The third stitch should be placed exactly opposite the attachment of mesentery; it is figured in Fig 363. It should be a very exact Lembert's suture and the ends are to be left long. The threads are then drawn in opposite directions, the circular suture being thus resolved into two simple longitudinal sutures. The invagination

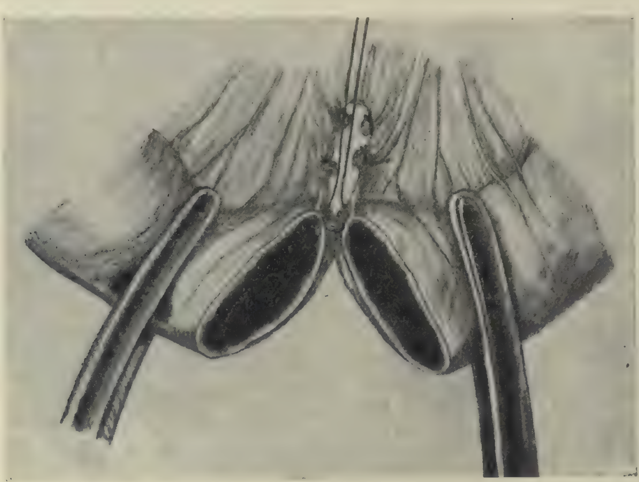

FIG. 362.—Resection of the small intestine. II. Stage. Introduction of the first stitch.

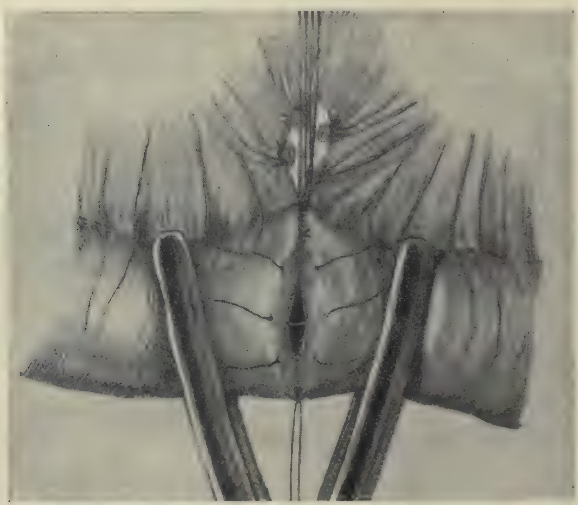

FIG. 363.—Resection of the small intestine. III. Stage. The opposing end-stitches are left long; the anterior sutures are being inserted.

having been completed on the anterior aspect, we then support the bowel on a fresh compress, turn the bowel and clamps on to the other side and complete the circular suture with a row of posterior Lembert's, as shown in Fig. 364. In this operation the stitches must be introduced with the greatest care and precision; if one of them is insecure and requires to be reinforced with an additional invaginating stitch, the spur may project unduly into the lumen and there will be a chance of constriction. Cut all the sutures off short, remove the clamps and test with the finger-tips whether the lumen is permeable. The operation is to be completed by suturing up the opening in the mesentery. The stitches grip the layers of the mesentery firmly and are not tied too tight, so as not to tear up the vessels unnecessarily. If there is enough material we may introduce invaginating sutures and leave a perfectly smooth peritoneal surface (*v* Fig. 365).

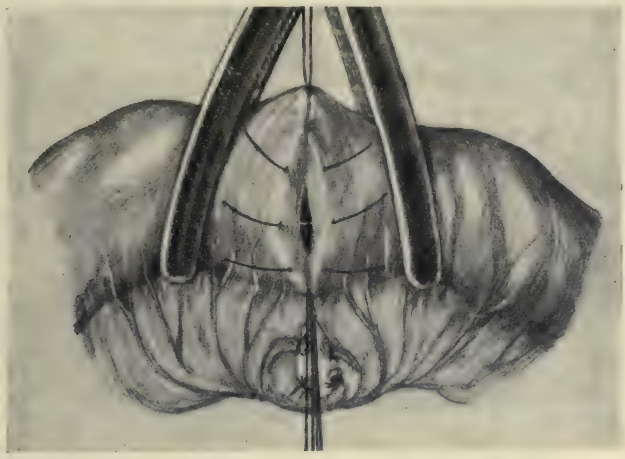

FIG. 364.—Resection of the small intestine. IV. Stage. Suture of the posterior aspect.

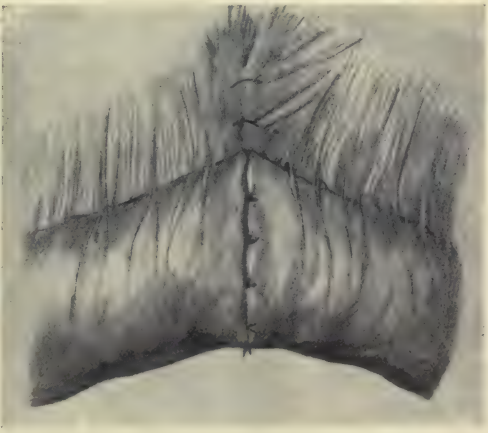

FIG. 365.—Resection of the small intestine. V. Stage. Suture of intestine and mesentery completed.

Another method of circular suture is illustrated in Figs. 366–369; it shows how circular anastomosis of the intestine can be carried out in two layers with a continuous suture. Fig. 366 shows the lumina lying side by side like the two barrels of a gun ; it also shows the posterior serosa suture and the way in which it is carried on as a posterior sero-serosa stitch to close the opening in the mesentery. Fig. 367 shows the posterior stitch

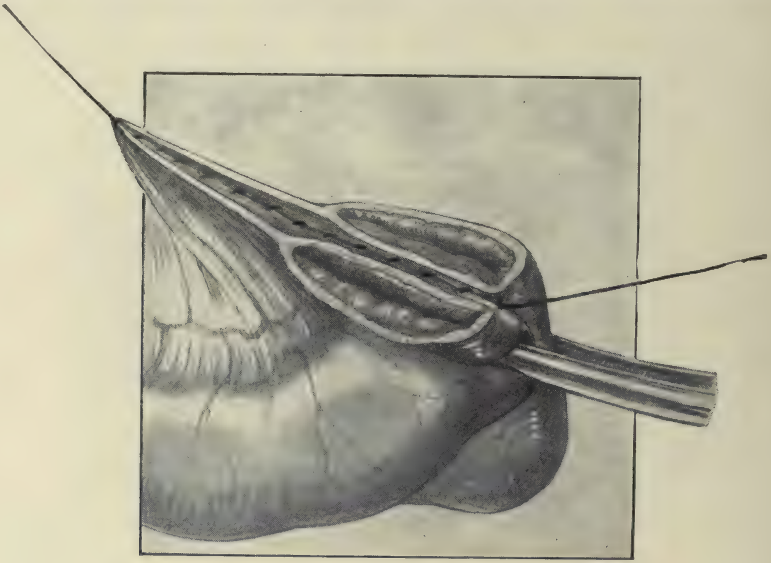

FIG. 366.—Resection of the intestine with subsequent circular anastomosis.

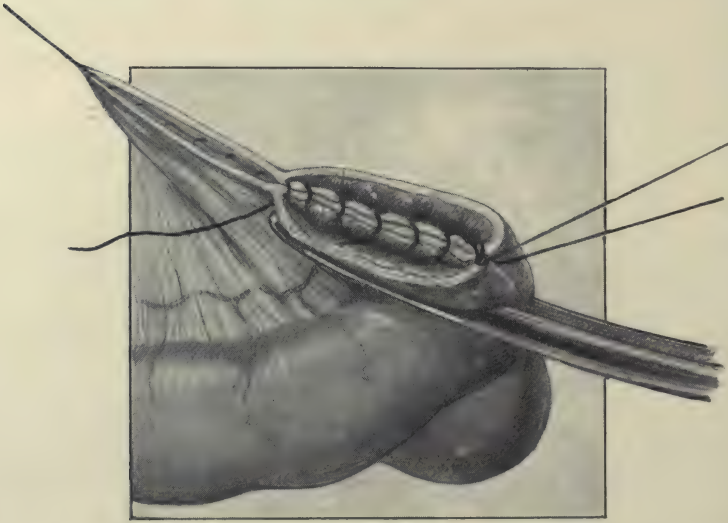

FIG. 367.—Resection of the intestine with subsequent circular anastomosis. II. Stage. The ends are united with an isoperistaltic anastomosis : the mesentery is then stitched up.

through the mucous membrane, and Fig. 368 the continuous anterior suture according to the author's method of invagination (cp. Fig. 318). Lastly,

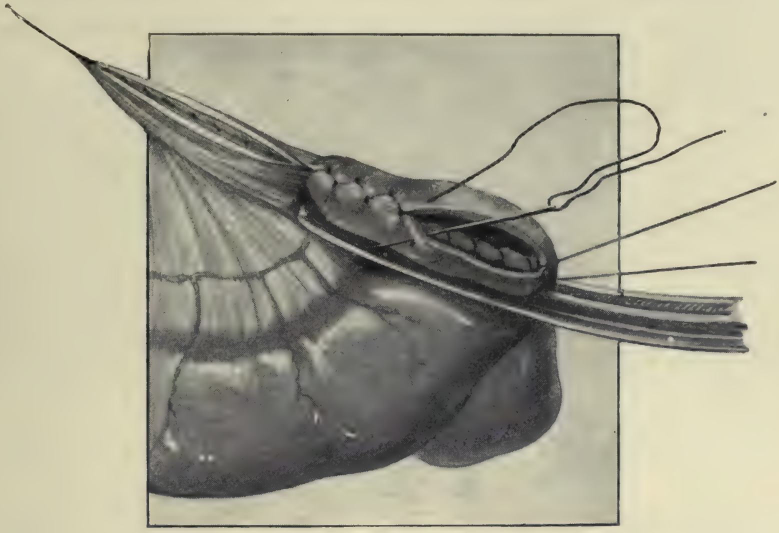

FIG. 368.—Continuous invaginating stitch of the anterior wall.

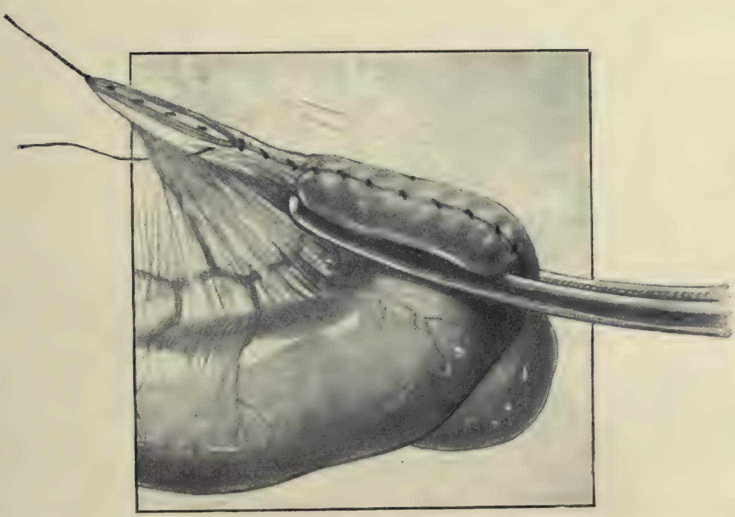

FIG. 369.—IV. Stage. Continuous anterior serosa stitch of intestine and mesentery.

Fig. 369 shows the anterior serosa stitch, which may be carried out with the initial suture; it is continued on to the serosa and closes the anterior layer of the peritoneum over the opening in the mesentery.

(*b*) *Resection with subsequent lateral anastomosis* (*Side-to-side anastomosis*).

If you regard the circular suture as insecure, it is better to perform the easier operation, *i.e.* Resection followed by lateral apposition. This is indicated wherever the lumina are of unequal size, as is generally the case in old-standing stenoses; the upper portion is then dilated and hypertrophied and does not fit the lower shrunken part. We proceed as follows:—Dissect bluntly through the mesentery close to its line of attachment and pass two strong sutures round the bowel; tie them tightly

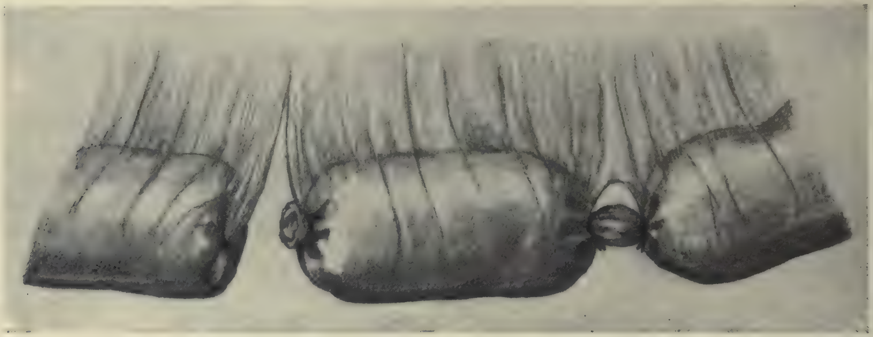

FIG. 370.—Resection of intestine with subsequent lateral anastomosis. I. Stage. Division and closure with the purse-string suture.

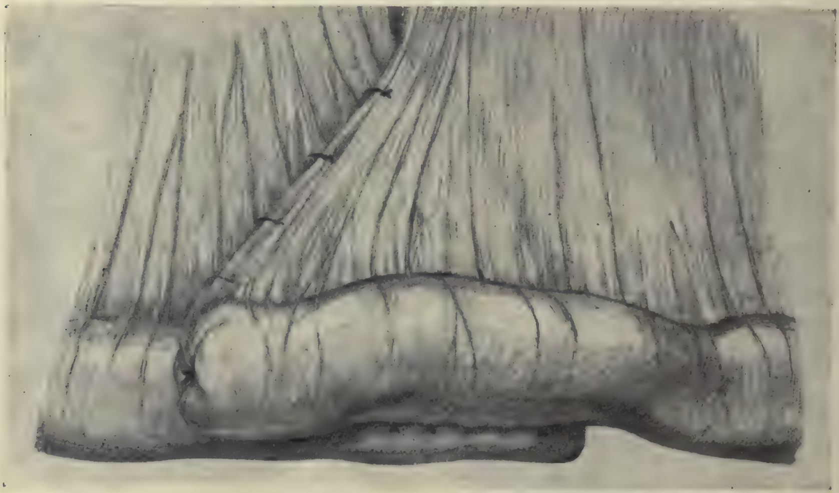

FIG. 371.—Resection of intestine with subsequent lateral anastomosis. II. Stage. Isoperistaltic approximation of the two ends, and union by lateral anastomosis; stitching up of the mesentery.

and knot securely. Divide the bowel between the two ligatures with scissors or the thermocautery. The enterotribe (*v.* Fig. 309) may be used to crush the bowel wall the ligatures being then passed round in the groove thus formed. Fig. 370 shows the two points of resection in different stages of the operation. The healthy ends of bowel are immediately closed with invaginating purse-string sutures, as illustrated in Fig. 308. The mesentery belonging to the diseased portion is ligatured off in bundles and divided. After removing the diseased portion, lay the closed ends of bowel together (with a view to *isoperistalsis*) (*v.* Fig. 371), and unite them with a typical lateral anastomosis (*v.* Figs. 311–319). Finish off the operation by uniting the overlapping layers of mesentery with a few sutures, to prevent any dangerous opening being left behind.

3. *Ileo-caecal Resection.*

Resection of the small intestine is comparatively easy as compared with the resection of disease in the ileo-caecal region (tumours, tuberculosis, etc.), for we have here to deal with a part of the gut that has a short mesentery; there is greater difficulty, therefore, in mobilizing and delivering it from the abdomen. Not only so, but the conditions in the great intestine are much less favourable for the healing of sutures and its contents distinctly more infectious; it follows that the responsibility of operating on the great intestine should never be lightly undertaken. The ileo-caecal region is exposed by a long incision at the outer edge of the right rectus muscle; this enables us to determine the amount to be resected.

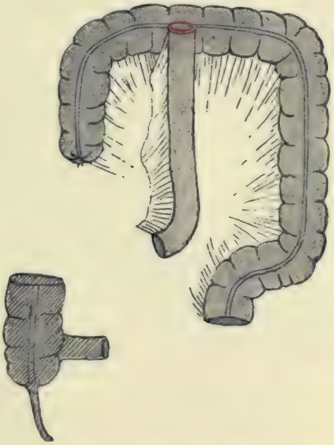

FIG. 372.—Ileo-caecal resection with lateral implantation of the small intestine into the transverse colon.

The usual method is to resect the ileo-caecum, close the distal end of the great intestine and anastomose the end of the small intestine into the movable transverse colon, as shown diagrammatically in Fig. 372. This is the method we shall describe. Commence by ligaturing off the mesentery at the lowest part of the small intestine; the place of resection should always be at least 4 in. (10 cm.) from the ileo-caecal valve, in order that the end of the small intestine may be freely movable.

Screen off the bowel with layers of gauze, tie two firm ligatures round the ileum and divide between them with the thermocautery; make a careful closure of the two ends by the Doyen purse-string method. Then, before proceeding further, unite the ileum to the transverse colon either by end-to-side anastomosis, as shown in Fig. 372 or 373, or by isoperistaltic lateral anastomosis (*v.* Fig. 374). Separate the mesentery from the small intestine, ligaturing off as you go till you come to the caecum ; draw it out and free it along its outer side from the external fold of peritoneal reflection, no ligatures being required as a rule. The caecum and first part of the ascending colon is now raised from the surrounding tissue by means of blunt dissection, and a view obtained of the retroperitoneal connective tissue space (cp. Fig. 374), where several important structures have to be preserved. First of all the ureter must not be injured or ligatured ; it crosses the psoas major muscle, and is crossed in its downward course by the spermatic vessels ; then in the upper angle of the retroperitoneal wound the lower pole of the right kidney and the infero-lateral part of the horseshoe-shaped duodenum are brought into view. Lift the caecum still further out and divide the mesentery at the inner border of the ascending colon, ligaturing off all the blood vessels as you proceed ; you have again to keep a watchful eye on the ureter, which must neither be injured nor ligatured as you work up to the point of intended resection. Pass a

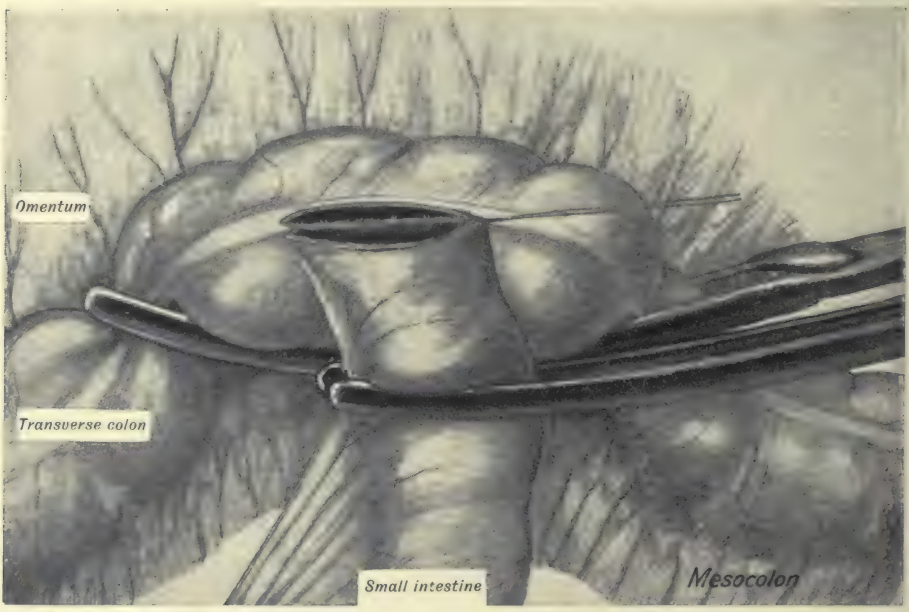

FIG. 373.—End-to-side anastomosis between small intestine and transverse colon. The posterior row of sutures and an end-stitch have been introduced ; the large intestine has been opened in the line of the taenia.

couple of stout ligatures round the colon at this point and divide between them with the thermocautery. This allows the resected ileo-caecum to be removed. The single purse-string suture which is sufficient for the small intestine will not do in the case of the colon ; several invaginating sutures are required and they must be inserted with care and precision in order to guard against the chance of perforation.

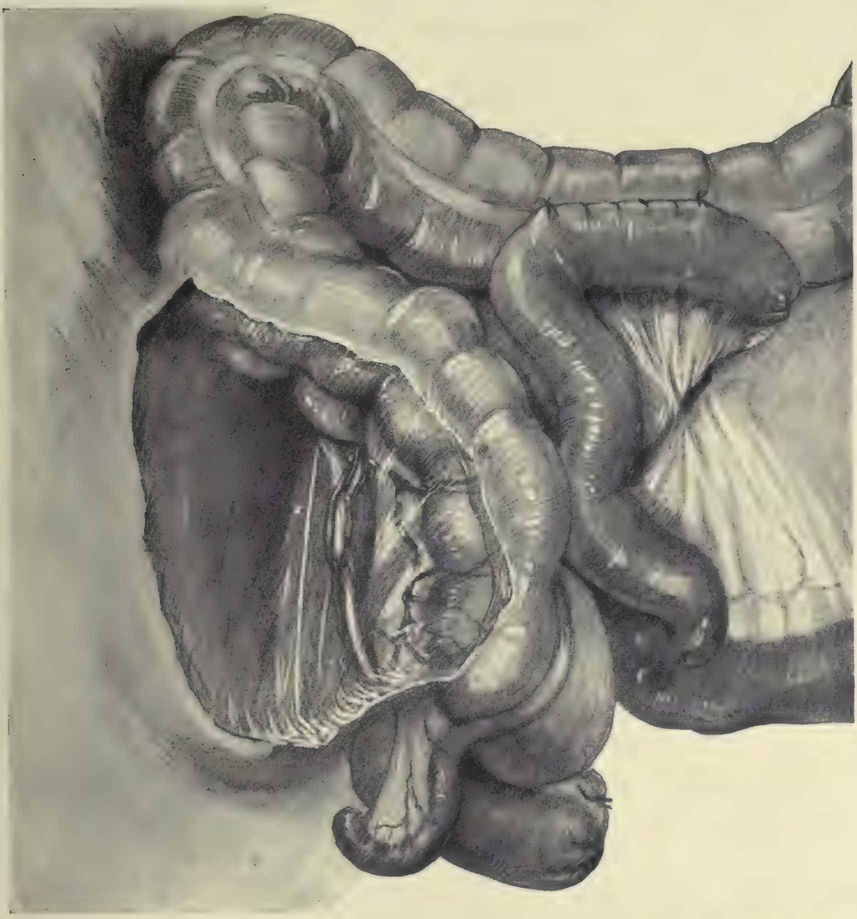

FIG. 374.—Ileo-caecal resection. Divide the ileum and anastomose the afferent end to the transverse colon Divide the peritoneum along the line of its outer reflection and lift the caecum towards the median line. The ureter, duodenum and lower pole of the kidney are seen in the background.

The implantation of the ileum into the transverse colon by end-to-side anastomosis is referred to above and is illustrated in Fig. 373. The great omentum is thrown upwards, and the end of the small intestine is applied to the free taenia of the transverse colon ; a large fold of the transverse colon is now caught up with a clamp, with the free taenia coli lying along the middle of it, and an incision is then made in the middle of the taenia through serosa and muscularis to correspond with the lumen of the small intestines. The posterior Lembert's sutures and the end-stitches are then introduced (cp. Fig. 373); the end-stitches should take an extra firm hold on the gut and are left long. The mucous membrane of the colon is then divided with the thermocautery, and the anterior row of sutures introduced in the usual way. This completes the end-to-side anastomosis. We thus get an imitation of the normal ileo-caecal orifice. It is always well to anastomose into the middle of the transverse colon, as this is the most movable part of the large intestine; the exclusion of the rest of the ascending colon and the hepatic flexure does not really matter, provided the stitches are not exposed to tension. Lastly, Fig. 375 illustrates how the small intestine may be taken after a complete ileo-caecal resection and implanted into the ascending colon by circular anastomosis. At the place where the caecum has been resected we are now confronted with a large cavity that has been deprived of its posterior parietal peritoneum; this is apt to bleed and lead to the formation of adhesions. The best way of closing it is by a continuous catgut suture which coapts the inner and outer layers of the resected mesentery.

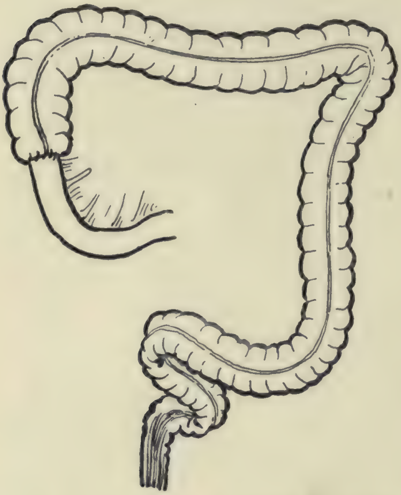

FIG. 375.—Diagram of ileo-caecal resection with circular anastomosis between ileum and ascending colon.

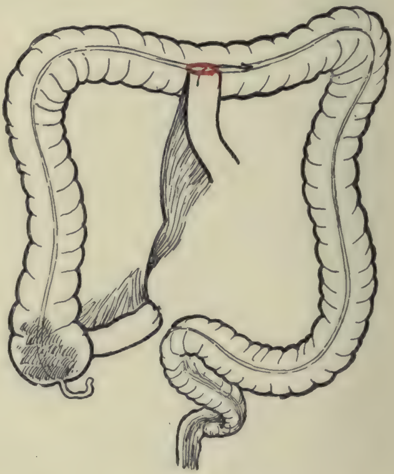

FIG. 376.—Diagram of ileo-caecal resection with cross section of the ileum and lateral implantation of the afferent limb into the transverse colon.

Ileo-caecal exclusion (*without resection*).

In some cases, *e.g.* tuberculosis and inoperable tumours, we may be obliged to exclude the ileo-caecum from the faecal circulation. The diagrams in Fig. 376 and Fig. 377 shows how this can be managed; in Fig. 376 by dividing the ileum, closing the distal end and anastomosing the afferent end into the transverse colon (end-to-side anastomosis); in Fig. 377 by excluding the diseased piece of gut both above and below (to avoid any back-flow of faeces) and by lateral anastomosis of the ileum to the transverse colon. One precaution, however, must never be overlooked in this operation of total exclusion—it is indicated in Fig. 377—the excluded portion of gut must always be connected to the exterior by means of a fistula, so as to carry out the secretions.[1]

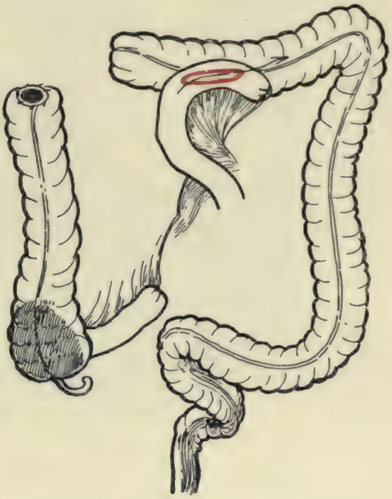

FIG. 377.—Diagram of total ileo-caecal exclusion with lateral anastomosis between ileum and transverse colon, and with a safety-fistula leading from the distal end of the ascending colon.

4. *Resection of the Large Intestine.*

What we have already said makes it perfectly clear that much greater care has to be exercised in resecting the colon than in the resection of the small intestine. It would carry us too far beyond the scope of this work if we were to describe all the various methods of resecting in one or more stages. Special rules are in force for almost every part of the large intestine; each part requires special study, for each has a different vascular supply and a varying length of mesentery. The determining factor is the length of the mesentery; resection is easy of execution in the freely movable parts of the large intestine (transverse colon, sigmoid flexure). Freely movable portions where the mesentery is long are brought out to the front like a piece of small intestine; fixed portions must either be operated on inside of the abdomen, or, when that is impossible, mobilized by more or less complicated methods, care being ever taken not to imperil the nutrition of the gut.

The circular stitch that is so simple in the case of the small intestine is not applicable to the large intestine except in the very rarest instances and its difficulties are such that many surgeons try to avoid it altogether. Lateral anastomosis is substituted for it, as illustrated in Fig. 378, *i.e.* double end-closure followed by anastomosis in the line of the two taeniae; of course this method is only applicable when the two ends are freely movable. The suture, and more especially the circular anastomosis, of the large intestine presents unusual difficulties:—these are, the frequent delicacy of its walls, its irregular form (due to the sacculations and the appendices epiploicae), and the lack of a complete peritoneal coat (in consequence of the breadth of the mesenteric attachment); if we also take into account the highly infectious nature of its contents and the thick faecal balls that are ever moving slowly along it, it can be understood how all the conditions are unfavourable for ready reunion of the bowel and uninterrupted healing of the stitches.

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[1] Faecal formation is not merely a mechanical process but an active secretion from the wall of the gut.—TR.

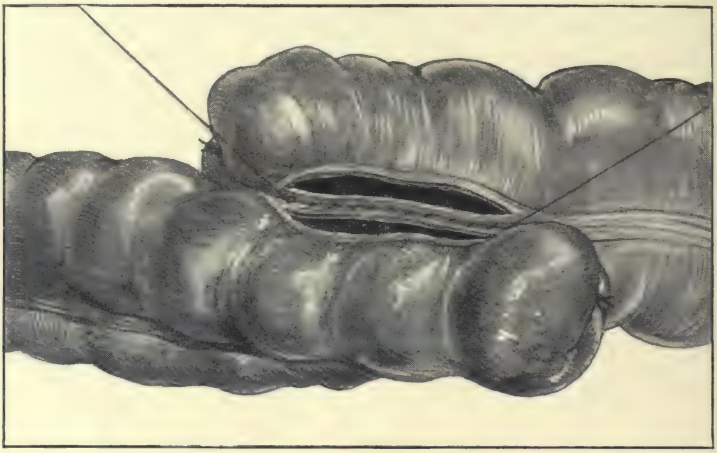

FIG. 378.—Representation of lateral anastomosis between two blind ends of large intestine subsequent to resection.

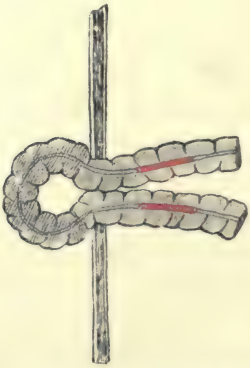

FIG. 379.—Resection of the large intestine. I. Stage. Delivery and anastomosis.

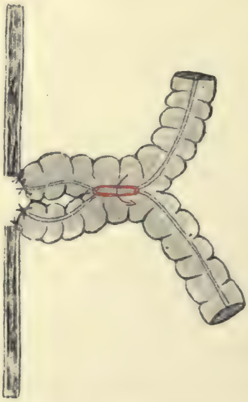

FIG. 380.—Resection of the large intestine. II. Stage. Anastomosis and end-closure.

The technique in resecting a movable part of a large intestine is much the same as in resection of the small intestine. A large and varying area of mesentery is removed in every case along with its contained glands. At least two rows of sutures should be inserted in the large intestine; they should be introduced with the greatest care and a piece of omentum stitched over the place whenever possible. There is always a danger in the large intestine of secondary perforation, and many authors have urged that insecure parts (and especially insecure end-closures) should be stitched into the anterior abdominal wall, the peritoneum closed and part of the abdominal wound left open; if perforation does occur it will then be to the outside and not into the peritoneal cavity. As the danger of infection is considerable in extensive operations in the large intestine, it is advisable to carry out the procedure illustrated in Figs. 379 and 380. Plan the abdominal incision to suit the position of the tumour, and deliver the part to be resected out of the wound. Free the colon from its attachment by doubly ligaturing off and dividing the mesentery; the separation must be continued till the whole of the diseased area is brought out to the front of the abdomen. A large lateral anastomosis is then made between the two deep adjacent limbs of the large intestine (Fig. 379)—the technique is described above. It

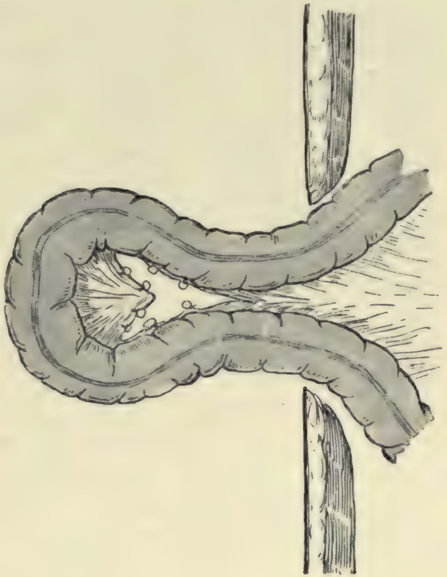

FIG. 381.—Resection of the large intestine (v. Mikulicz). I. Stage. Double ligation and separation of the mesentery from the diseased bowel.

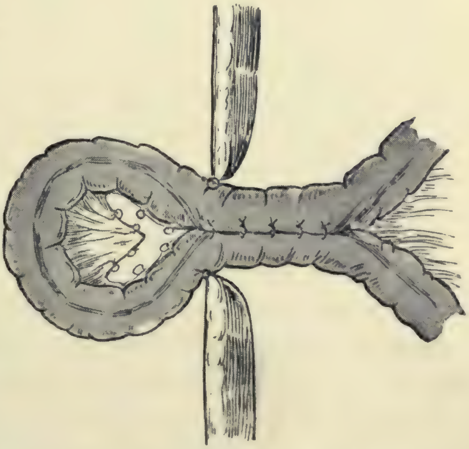

FIG. 382.—II. Stage. The afferent and efferent limbs of intestine are anastomosed and replaced; the part to be removed is stitched on the outside.

is of great importance to place the anastomosis in the part of the gut whose mesenteric connections are quite intact, or else its nutrition may suffer. The anastomosed limbs of gut are then allowed to sink back into the abdomen and the opening in the peritoneum closed with a circular stitch. Elastic clamps are next applied to the part deprived of mesentery, and the part to be resected is removed. The ends are now lying outside the abdominal cavity and should be closed with several invaginating sutures. In other words, knowing that perforation of the ends is a common accident we bring them out through the abdominal wall into an extraperitoneal position (Fig. 380). This method gets rid of the disease and secures primary reunion of the gut at one and the same time; it is, therefore, a one-stage operation, resembling simple resection of the large intestine with subsequent circular anastomosis.

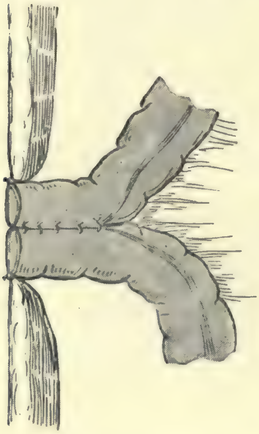
FIG. 383.—III. Stage. The portion delivered is removed secondarily; a double artificial anus is the result.

v. Mikulicz has planned a two-stage method. Its aim is to lessen the dangers associated with every big resection of the large intestine, firstly by removing the risk of infection, and secondly, by dividing the operation into two stages. It is carried out as follows:—Mobilize the part of the large intestine to be resected, ligature off and divide the mesenteric connections and bring the bowel with its associated lymph glands out to the front of the abdomen (Fig 381). Stitch together the afferent and efferent limbs of gut with a single row of sutures but without opening the bowel. The two parallel limbs of gut are now replaced in the abdomen, and the part to be removed is brought out and stitched in place with a circular peritoneal suture (Fig. 382). Close up the greater part of the abdominal wound round the protruding portion of bowel. This protruding part necroses rapidly in consequence of its vascular connections being divided and may be cut away in a few days. We thus get

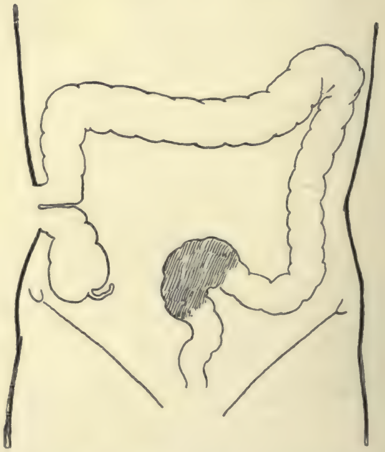
FIG. 384.—Resection of large intestine in three stages. I. Stage. An artificial anus has been established above the tumour.

a double artificial anus (Fig. 383) which can be closed up at a second sitting.

The risks attending resection of a diseased large intestine are materially increased when stenosis and faecal impaction have already supervened. The patient cannot be prepared for operation by emptying the lower bowel, and the intestinal wall may have become altered to such an extent that no confidence can be placed in the stitches; add to this, that the patients are often too run-down for any major operation to be attempted, and it becomes evident that we dare not do more than establish a single artificial anus above the seat of the disease.

This consideration led Schloffer to resect the large intestine in three stages: the method is especially applicable to tumours of the sigmoid flexure, but is not advisable when there are marked signs of faecal impaction. The first step is to make an artificial anus at the caecum (Fig. 384); the bowel is allowed to empty itself of faeces, and the resection is carried out at a second sitting (Fig. 385); the artificial opening is closed at a third sitting. The result of the operation is shown in Fig. 386.

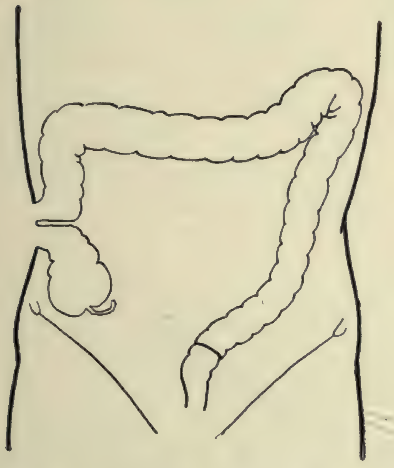

FIG. 385.—II. Stage. The tumour has been resected, but the artificial anus is left open.

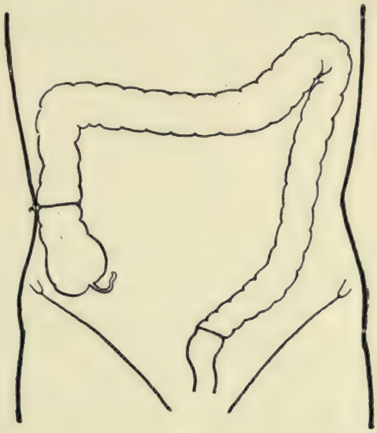

FIG. 386.—III. Stage. The operation has been completed with the closure and artificial anus.

5. *Appendicectomy.*

Removal of the appendix is easy or difficult according to the extent of the adhesions. It is only the uncomplicated operation that can be performed on the dead subject. The abdominal incisions for exposing the caecum have been already described. The protruding coils of the small

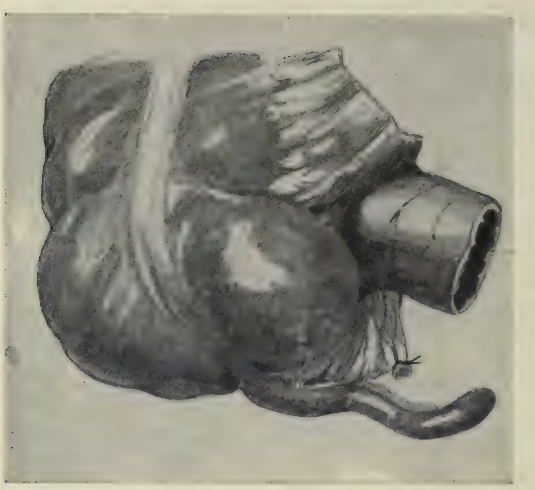

FIG. 387.—Appendicectomy. I. Stage. Ligature of the mesoappendix.

intestine are forced back, and the great intestine (caecum, or ascending colon) seized with dissecting forceps. We must now expose the appendix as rapidly and yet as gently as possible. The way to do this is to find the anterior taenia coli and follow it vertically downwards to the root of the appendix (*v.* Fig. 387). Having found the appendix, gently separate it from its surroundings and deliver it through the wound. Fig. 387 shows how the mesentery is to be ligatured off in one or more pieces. Fig. 388 shows how the appendix is ligatured close to its root, seized with a small Pean's clamp and divided. Fig. 389 illustrates how the stump is surrounded with a purse-string suture; this may be introduced before the appendix is divided. Finally (*v.* Fig. 390), the stump of mesentery is stitched over the point of invagination, and it only remains to drop the caecum back into the abdominal cavity.

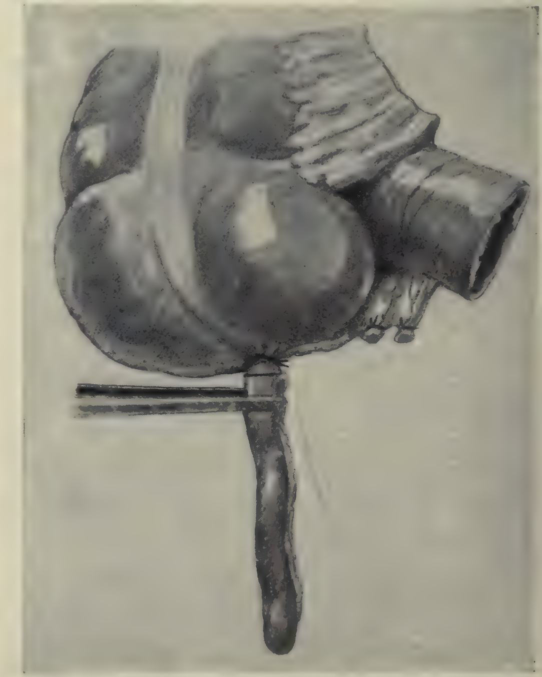

FIG. 388.—Appendicectomy. II. Stage. Ligature, clamping and removal.

6. *Colostomy and the Formation of an Artificial Anus.*

To establish an artificial anus is an operation of great practical importance. It may be wanted in cases of emergency—*e.g.* in intestinal obstruction or peritonitis—and

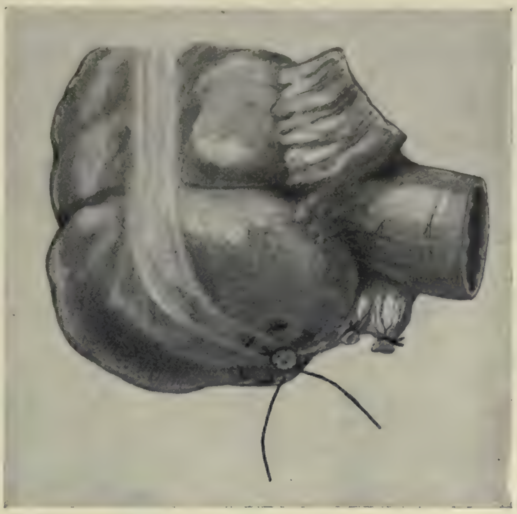

FIG. 389.—Appendicectomy. III. Stage. Treatment of the stump by purse-string suture.

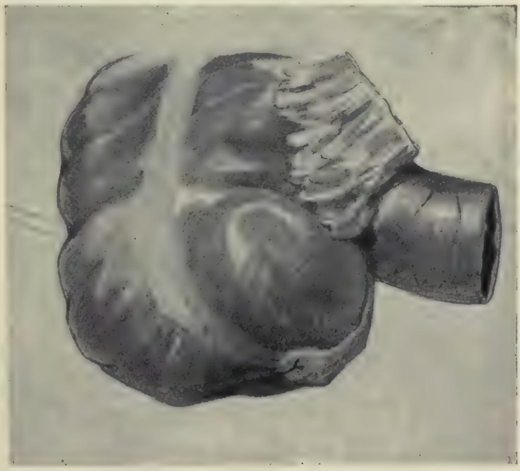

FIG. 390.—Appendicectomy. IV. Stage. Fixation of the mesoappendix to the site of suture.

has often to be performed with a simple and rapid technique in these conditions and in distentions of the small and large intestines. The idea of the operation consists simply in stitching an area of intestine the size of a two-shilling bit to the peritoneum of the abdominal wall, as illustrated in Figs. 391 and 392. Wherever possible, the different layers of the abdominal wall should be guarded against faecal effusions by stitching the edges of the parietal peritoneum to the external cuticle by means of a continuous circular suture. The gut is opened by a simple puncture; wherever possible, a tube should be stitched in, care being taken to make it water-tight (colostomy).[1]

The typical operation for an artificial anus is quite different; the idea here is to lead off all the faeces to the exterior and try to render this condition permanent. The intestine must therefore protrude to the extent shown in Fig. 394, *i.e.* an entire coil with its mesentery. The sigmoid flexure of the descending colon is available for this purpose on account of its mobility.

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[1] Paul's tubes may be used for tiding the patient over a difficulty, for relieving flatus and lessening toxaemia. These are glass tubes bent in the middle and flanged at both ends. A piece of the bowel is pulled through an opening in some indiarubber sheeting; the bowel is then opened and the tube inserted and fixed. Faecal contamination is thus prevented. The tube is usually taken out after twenty-four hours, *i.e.* after the peritoneum has become sealed off.—TR.

The abdominal incision is either No. 10 or No. 11, as represented in Fig. 277. We seize the most convenient coil of colon and draw it out; the colon is recognized by its sacculations, its taeniae and its numerous appendices epiploicae. Introduce a stay suture and replace the bowel; the suture enables one to find it again at once. Then stitch up the free edges of the skin and peritoneum with a continuous catgut suture, as shown in Fig. 395, draw out a good piece of the colon and stitch the two limbs of the coil together with a few sutures (*v.* Fig. 396), so that they lie parallel to

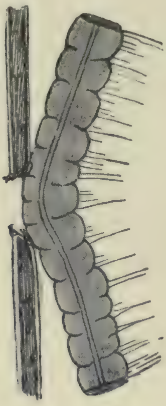

FIG. 391.—Diagram of faecal fistula in the large intestine (colostomy).

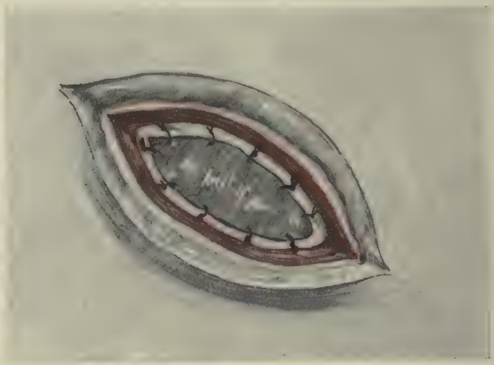

FIG. 392.—Lateral colostomy. I. Stage. A coil of intestine is stitched into the parietal peritoneum.

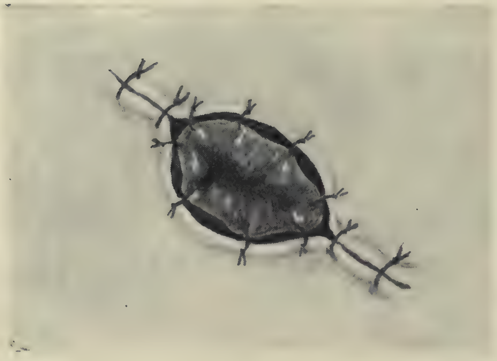

FIG. 393.—II. Stage. The bowel is then opened and its edges stitched to the edges of the skin.

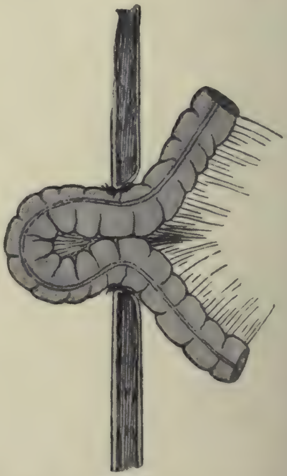

FIG. 394.—Diagram of artificial anus into the large intestine (anus praeternaturalis).

each other: we thus get a protruding horse-shoe coil of bowel and this is to be fixed all round to the abdominal parites by stitching the intestinal peritoneum to the parietal peritoneum. No spaces are to be left, even for the introduction of a finger-tip, or else the abdominal viscera might force their way out. In order to secure a firm hold on the coil of large intestine and draw bowel and mesentery to the front of the abdomen, an opening

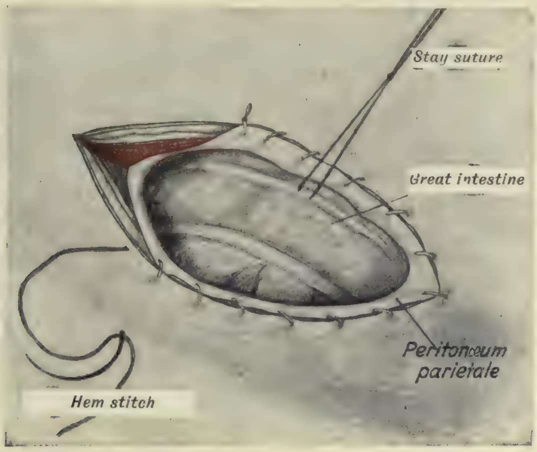

FIG. 395.—Establishment of an artificial anus. I. Stage. Suture of the peritoneum to the outer skin after introduction of a stay suture.

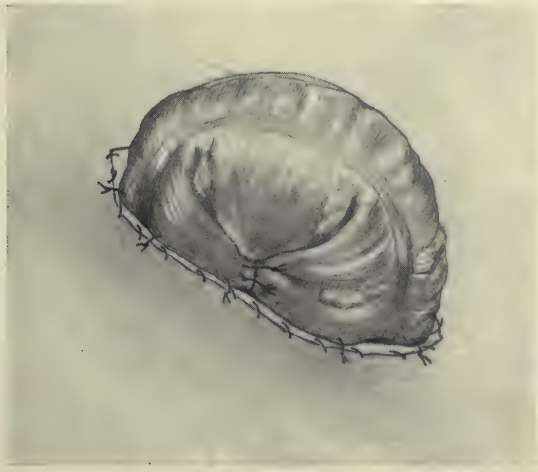

FIG. 396.—Establishment of an artificial anus. II. Stage. Unite a loop of great intestine with a few stitches into the form of a horseshoe. Stitch the horseshoe loop all round to the peritoneum.

can be made in the mesentery, a strip of gauze or a drainage tube passed through it (cp. Fig. 397), and the bowel stitched into place. The bowel is not opened at once, but is allowed to heal up in the new position ; it is only after a few days that we divide it with the thermocautery and secure a double-mouthed opening.

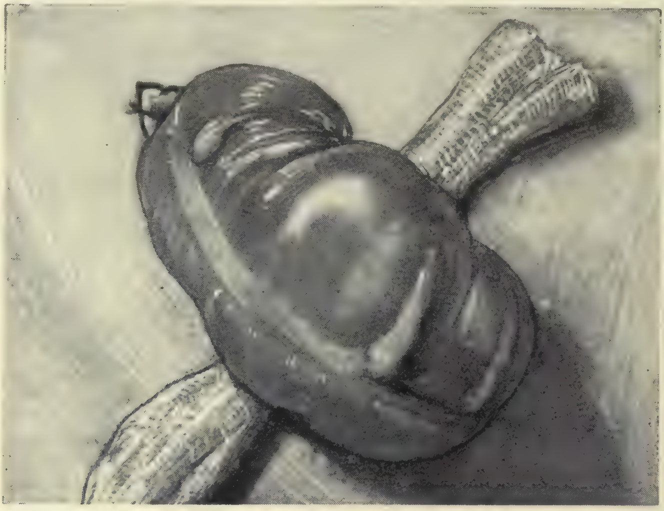

FIG. 397.—Formation of a double artificial anus ; a strip of gauze has been drawn through a hole in the mesosigmoid.

(Rectal operations are considered in Section VI., No. 9, Figs. 266 to 274.)

C. OPERATION ON THE GALL-BLADDER AND BILIARY TRACT.

1. *Exposure of the Biliary System.*

Only a few of these operations can be practised on the subject ; we shall therefore describe only the more important and explain them by means of diagrams. The chief thing to practise is the exploration of the whole biliary tract ; pathological variations are frequent, and in many cases interesting. The beginner thus prepares himself to meet the conditions that exist in real life.

In commencing the exposure of the biliary tract, the operator should bear the accompanying diagram (Fig. 398) constantly in mind. The right and left hepatic ducts issue from the transverse fissure of the liver and unite to form the hepatic duct. This common duct has a side duct running into it, the cystic duct ; the latter ends in the cul-de-sac of the gall-bladder, which adheres to the under surface of the liver. Below the cystic duct the main biliary passage goes by the name of the common bile duct; it opens at the papilla of Vater in the posterior wall of the descending part of the duodenum.[1] Great vessels accompany the bile duct up to the transverse fissure; these are the portal vein and the hepatic artery. The portal vein lies very near the bile duct, but to the inside and behind; the hepatic artery lies to the inside of the duct, but in front of the vein. The gastro-duodenal artery arises from the hepatic artery and runs downwards; the hepatic artery itself gives off a small branch—the cystic artery, which passes in front of or behind the cystic duct to the gall-bladder. The whole system of the biliary tract and associated blood-vessels lies in the lesser or gastro-hepatic omentum; introduce the left forefinger into the foramen of Winslow from the right side and hook up the lesser omentum from behind; the common bile duct then lies in front and to the right of the others. We use the gall-bladder as an indicator in exploring the biliary passages; the fundus presents at the anterior edge of the liver, and we are able to trace the cystic duct back from the fundus, along the inferior free peritoneal surface of the bladder and onwards to the common duct. Finally expose the retroduodenal part of the common bile duct, the deepest and most inaccessible structure in the surgery of gall stones. To expose it we proceed at once to carry out Kocher's method of mobilising the duodenum. Make a vertical incision through the posterior peritoneum a finger's-breadth to the right of the descending limb of the duodenum, free the descending limb of duodenum and turn it over towards the stomach.

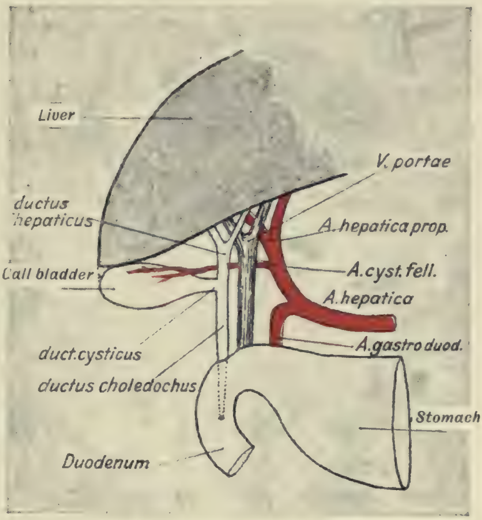

FIG. 398.—Diagram of the biliary tract and associated blood-vessels.

The most useful abdominal incisions for the biliary tract are shown in

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[1] The gall-bladder and cystic duct meet the common bile duct at an angle. At this angle the mucous membrane of the cystic duct protrudes into the interior forming the "spiral valve" and rendering the passage more or less tortuous. Stones are apt to be caught here in the pockets of the mucous membrane. The common duct becomes very narrow at its entrance to the duodenum and stones tend therefore to lodge in the ampulla of Vater.—TR.

Figs. 276 and 277, Nos. 6 and 7. In the subject it is best to employ Courvoisier's long-curved incision, a finger-breadth below and parallel to the right infracostal margin (No. 7). The subject lies on the back; insert a sand-bag or wooden block at the small of the back in order to produce a marked lordosis. This makes the wound gape open and secures us readier access to the deep organs under the liver. The position of the assistants is of great importance to the surgeon; he himself stands to the right of the abdomen; one assistant stands on his left and retracts up the infracostal margin and lower edge of the liver during the whole operation; the other assistant stands opposite the surgeon, and draws the stomach and pylorus to the left and the transverse colon downwards. The operator thus obtains a full view of the parts and is in a position to palpate the whole biliary tract.

2. *Cholecystotomy.*

This is the simplest operation of the series; the gall-bladder is opened in order to remove stones; a simple longitudinal abdominal incision is generally sufficient. The surgeon grasps the fundus of the gall-bladder with three Kocher's clamps, applying them in a circle, and draws it out into the wound. He then thrusts an aspirator into the fundus and sucks out all the bile. It is then safe to open the gall-bladder and clear out its contents (*v.* Fig. 399). The cystic duct can be probed from the gall-bladder. The ideal cholecystotomy is to suture up the opening after emptying out the contents; stitch the opening with a fine continuous catgut suture and invaginate the line of suture with a fine silk Lembert. Stitch the wound in the abdomen.

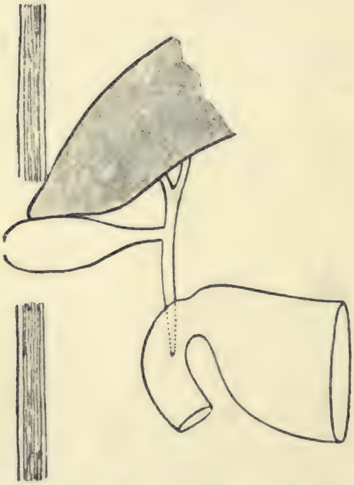

FIG. 399.—Diagram of cholecystotomy.

3. *Cholecystostomy.*

It is usually impossible to close the gall-bladder at once and we then require to drain off the secretion or the bile itself. In this case the gall-bladder should be stitched to the parietal peritoneum (*v.* Fig. 400). The bladder may be stitched to the abdominal wall, either after it has been opened and emptied, or immediately after the abdominal incision. Again the opening of the bladder may either be done in the first instance or may be postponed for a few days till after firm adhesions have formed. We must always see that the peritoneal coat of the gall-bladder is stitched to the parietal peritoneum; on no account should the gall-bladder be stitched to the skin or a permanent fistula will result. This biliary fistula is kept open by means of a thick tube as long as may be required. The fistula closes on the removal of the tube, provided that the common bile duct is patent. The gall-bladder, however, adheres to the scar in the abdominal wall. Poppert's method enables one to avoid this difficulty. He does not stitch the gall-bladder to the wall of the abdomen, but inserts a drainage tube and stitches it in place, invaginating the wall of the gall-bladder at the same time and sealing it all round with a purse-string suture; he then brings the tube through the external wound and stitches up the skin. Before the tube manages to escape from the bladder, numerous adhesions have formed. This procedure is illustrated in Fig. 401.

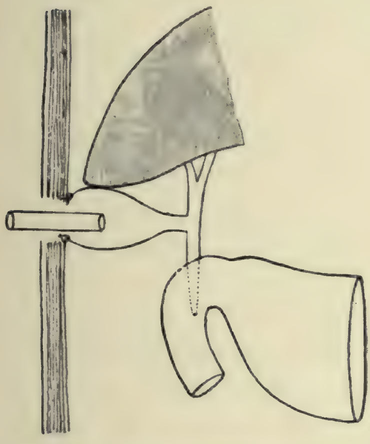

FIG. 400.—Diagram of cholecystotomy with drainage.

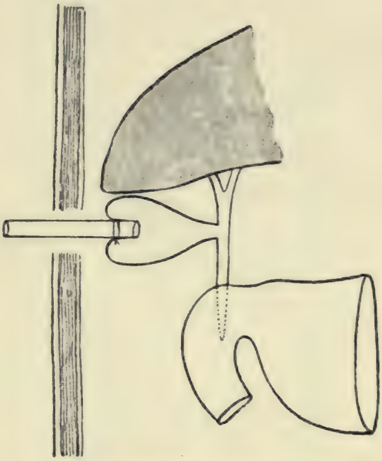

FIG. 401.—Diagram of drainage of the gall-bladder (after Poppert).

4. *Cholecystectomy.*

Extirpation of the gall-bladder may be undertaken when the bladder is diseased and the deeper ducts are not implicated or obstructed; a necessary preliminary to such an operation is to make a careful exposure and palpation of the entire biliary tract. The aim of the operation is to remove the gall-bladder and cystic duct as far as the entrance of the latter into the common bile duct. It is immaterial whether we begin the separation at the fundus of the bladder or at the cystic duct. We shall describe the former of these methods. The gall-bladder has firm adhesions to the liver at its attached surface. The bladder may be punctured and emptied if you consider it necessary; then free it from the anterior edge of the liver with a few snips of the scissors; avoid incising the bladder or cutting into the liver substance, for the liver bleeds freely when cut. The best way to separate the gall-bladder from the liver is to follow up the areolar tissue space that separates the two viscera; the deeper one goes, the easier it is, and finally all that remains is to free the neck of the gall-bladder and the cystic duct. It falls to be noted that the cystic artery runs along the upper border of the cystic duct; if it can be isolated, it should be ligatured by itself. It is now possible to expose the cystic duct as far as the common bile duct; ligature it securely at two points close up to the common duct, clamp the cystic a little in front of this and divide it between clamp and ligatures; the gall-bladder comes away at the same time (*v.* Fig. 402). Whenever possible draw the peritoneum together over the stump of the cystic duct; nevertheless we never neglect to employ drainage also as indicated in Fig. 402. Carry one of the catgut ligatures from the cystic duct through an elastic tube, carry the tube through the wound in the abdomen and fasten the thread at the outer end of the tube; this keeps the tube in position till the catgut is absorbed. The bed of the gall-bladder on the under surface of the liver bleeds easily and a tampon should be applied.

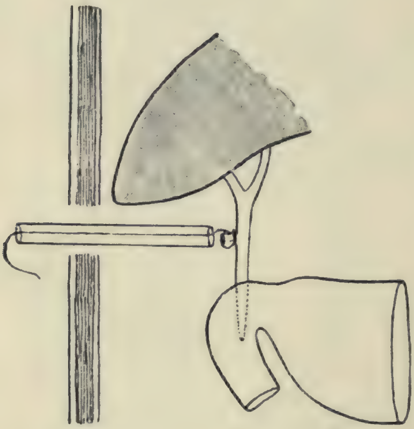

FIG. 402.—Diagram of cholecystectomy with drainage of the stump.

The gall-bladder may be removed in the reverse way: commence with a careful ligature and division of the cystic duct and working from behind separate the gall-bladder from the edge of the liver. The details and treatment of the wound are the same as above described.

After the gall-bladder has been removed there still remains a wound on the surface of the liver; this may give rise to bleeding, and may form adhesions to other abdominal organs if left to heal by itself. An attempt must be made to obliterate the raw surface, or at least to draw its edges together. A good plan is to perform subserous excision of the gall-bladder, or at least to retain enough of the peritoneal coat to cover the raw liver substance.

5. *Choledochotomy.*

This is the most difficult but the most useful operation in the surgery of gall stones. A gall stone may lodge in any part of the biliary tract; we therefore distinguish the operations of cysticotomy, hepaticotomy and choledochotomy, the last of which is the most important. If the stones are not firmly embedded, it is often possible to push them from an unfavourable into a more favourable position; this is most frequently performed in the case of the cystic duct; we try to force the stones from the duct into the gall-bladder. In the common bile duct the difficulty of the operation depends mainly upon the situation of the stone; if we follow the anatomical rules above described it is comparatively easy to expose and open the supraduodenal part of the duct; a stone impacted in the retroduodenal part is much more difficult to excise. In the latter case we can either mobilize the duodenum (Kocher's method), or open the duodenum and explore the lowest part of the biliary tract from the papilla of Vater (transduodenal choledochotomy). We shall confine ourselves to a description of supraduodenal choledochotomy, which is easy to practise on the subject (*v.* Figs. 403 and 404).

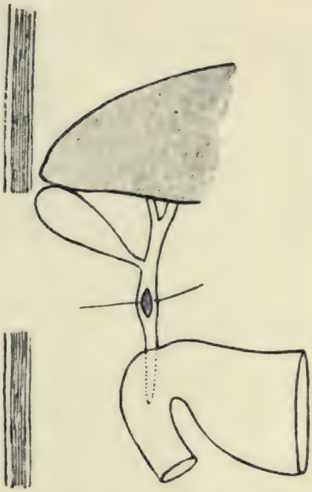

FIG. 403.—Diagram of choledochotomy.

After exposing the biliary tract in the usual way, divide the gastro-hepatic omentum at the place where you would expect the common duct to be and isolate it by blunt dissection; this is greatly facilitated by retracting up the gall-bladder and drawing down the duodenum in the opposite direction. As soon as you see the duct, seize it with fine forceps and open it with a linear incision (opposite the stone in the living subject). Next seize the edges with Pean's forceps, and evert them with a fine silk suture on either side; swab any bile that flows out (*v.* Fig. 404). Introduce a probe and pass it upwards into the hepatic duct and downwards through the retroduodenal part of the common bile duct into the duodenum. It is unusual to close the opening in the duct: hepatic drainage is the rule. Choose a rubber tube to suit the lumen of the duct and carry it up to the hepatic duct; then stitch it with the finest catgut to the opening in the wall of the common duct and with the same suture coapt the edges of the duct all round. This tube drains off the bile for as long as the surgeon deems desirable. Swab carefully all round the tube, and make a partial suture of the wound. Choledochotomy is often combined with cholecystectomy.

6. *Cholecystenterostomy.*

There are various methods available when the bile duct is extensively destroyed or no longer permeable; a new way has then to be found for the exit of the bile into the intestine. Surgeons have laboured to connect the duodenum with the end of the common bile duct or with the hepatic duct; they have even gone the length of connecting it with the biliary passages of the liver. Where it is only the common duct that is obstructed and both the gall-bladder and the cystic duct are quite permeable, the best way is to establish a cholecystenterostomy and to lead the bile into the duodenum through the hepatic duct, cystic duct and gall-bladder (*v.* Fig. 405).

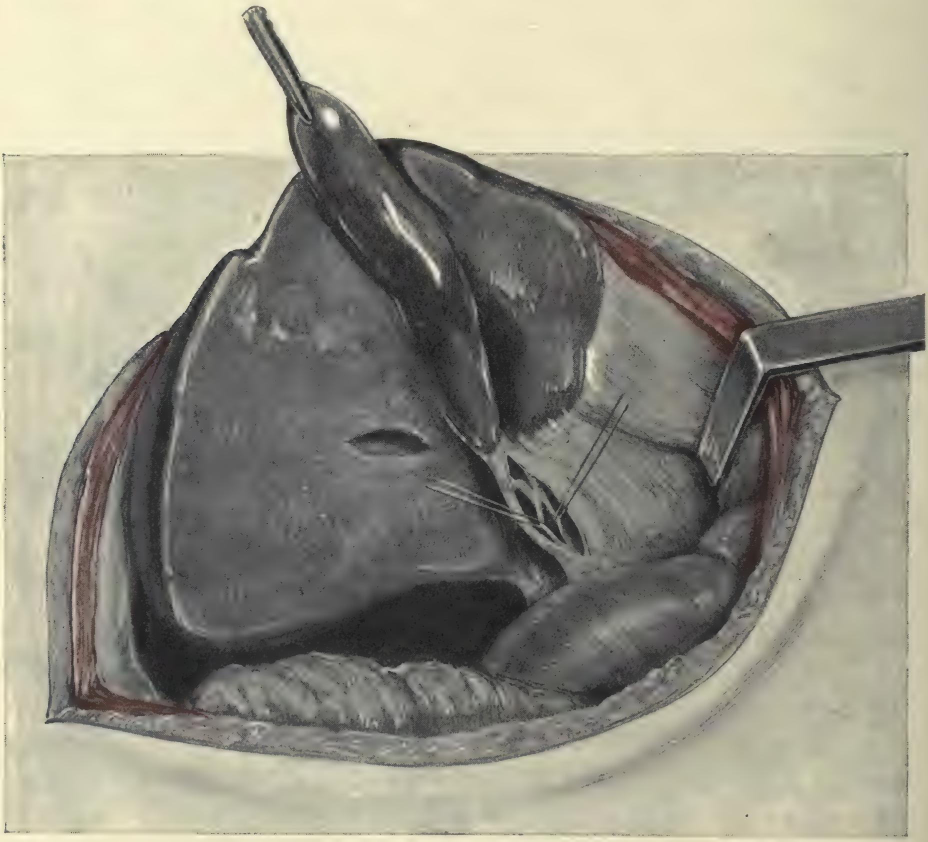

FIG. 404.—To illustrate choledochotomy.

The simplest method is to mobolise the duodenum and connect it with the under surface of the gall-bladder (cholecystoduodenostomy). Another way is to imitate posterior gastroenterostomy and make an opening in the transverse mesocolon ; draw up a high coil of jejunum aad anastomose it with the gall-bladder, mobilising the latter if necessary (retrocolic cholecystojejunostomy). On finishing the anastomosis draw the coil of intestine into the general abdominal cavity and stitch the mesocolon all round the point of anastomosis. The connection between gall-bladder and intestine can often be made with a small Murphy's button ; but it is just as good to perform a circular suture of the serous coats and stitch up the two openings ($\frac{1}{2}$–$\frac{3}{4}$ in., 1–2 cm. long) as in an end-to-side anastomosis of the intestine.

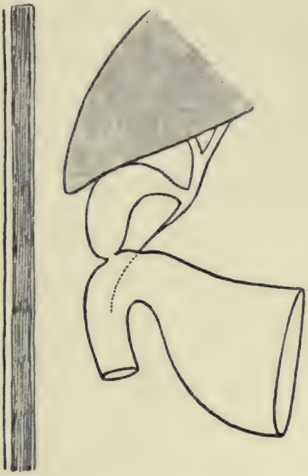

FIG. 405.—Diagram of cholecystenterostomy.

SECTION VIII

OPERATIONS ON THE UROGENITAL SYSTEM[1]

A. Operation on the Kidneys and Ureters

1. *Exposure of the Kidneys.*

SIMON was the first to extirpate the kidneys. He chose the lumbar retroperitoneal route, which still dominates the renal surgery of to-day. Subsequently the transperitoneal route was frequently employed; nowadays, however, this method of reaching the kidney has been in large measure abandoned and is reserved for special cases. We propose to consider only the lumbar methods of operation; the lumbar route is to be preferred as causing less injury and being less risky, for it is the shortest path to the kidneys and it is impossible to overestimate its advantages in the after treatment.

The anatomical relationships of the kidneys and the lines of incision are illustrated in Figs. 406 and 407; note that the kidneys lie for the most part under cover of the costal margin, indeed it is unusual for more than a third or a quarter of the organ to appear from below it. They lie opposite the XII. dorsal and the I.–III. lumbar vertebrae lateral to the origin of the psoas muscle. It is impossible to expose a normal kidney completely by means of a lumbar incision; it has first to be luxated from under the ribs into the operation wound. The right kidney lies as a rule slightly lower than the left, and floating kidney is more common on the right side; in this affection the organ is abnormally situated and abnormally mobile. The axis of the two kidneys do not lie parallel but cut each other when prolonged upwards. The renal stalk is formed by the renal vein, renal artery and ureter. The artery is a large branch that springs at right angles from the aorta at the level of the second lumbar vertebra: in the renal stalk it lies between the vein in front and the ureter behind. Even when the kidneys have been freed from all adhesions they remain firmly fixed, and often so securely that we have great trouble in delivering them into the wound.[1] Vascular anomalies are not at all rare; accessory veins are especially common, leaving the renal parenchyma some distance from the hilus. The ureter on leaving the hilus turns abruptly downwards and then slants down and inwards on the psoas muscle. Each kidney is enclosed in a capsule of connective tissue; this again is surrounded by a fatty envelope of very variable thickness. In exposing the kidneys we strip off the capsula adiposa, but leave the capsula propria intact.

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[1] Only operations on the male genitalia are here described; for operations on the female genitalia reference should be made to Liepmann's "Course of Gynaecological Operations."

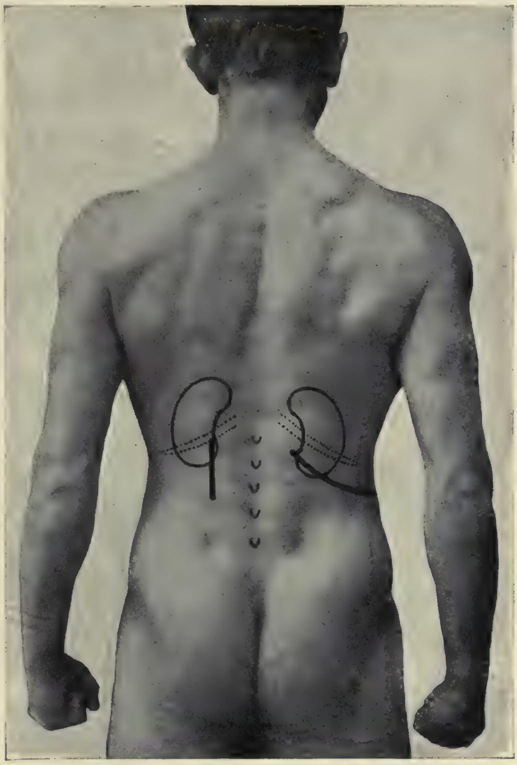

FIG. 406.—Diagram showing the position of the kidneys, the twelfth rib (dotted) and the spinous processes of the five lumbar vertebrae. The heavy line on the left corresponds to Simon's longitudinal incision, the right one corresponds to v. Bergmann's oblique incision.

To operate successfully on the kidneys the surgeon must have a clear idea of their relation to the peritoneum. The course of the peritoneum is seen in Fig. 407; it follows the course of the fascia transversalis, with only a little extraperitoneal tissue intervening; it is then reflected near the convexity of the kidneys on to their anterior surface. The kidneys and their perirenal fat are thus completely retroperitoneal, though lying close against the peritoneum. It follows that the latter is often implicated in disease of the kidneys (tumours, perinephritis).

The arrow in Fig. 407 indicates how the kidneys can be reached from behind. The long musculature of the back, the erector spinae and quadratus lumborum muscles are left intact; by deep palpation we can often make out the outer edge of the erector spinae, which represents the inner limit of our incision. The two oblique and transversalis muscles are seen to the outside; the higher the incision is placed, the more the latissimus dorsi is brought into the wound. The fascia transversalis extends between the muscles and the perirenal fat.

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[1] The inferior vena cava lies in very close proximity to the right kidney.—TR.

Two incisions are shown in Fig. 406 :—

(a) A linear incision at the edge of the erector spinae (Simon). It starts from the twelfth rib and runs some 4 in. (10 cm.) vertically downwards. It avoids nearly all the muscle fibres and does not endanger the peritoneum ; it is a strictly conservative incision. But it affords a partial survey at best, and permits only small kidneys and ones that are not abnormally fixed to be luxated. We therefore do not employ Simon's incision except when the kidneys are left in situ (nephropexy and opening of perinephritic abscesses).

(b) v. Bergmann's oblique incision, which may be taken as the type of the numerous incisions that divide the lateral musculature obliquely or transversely.

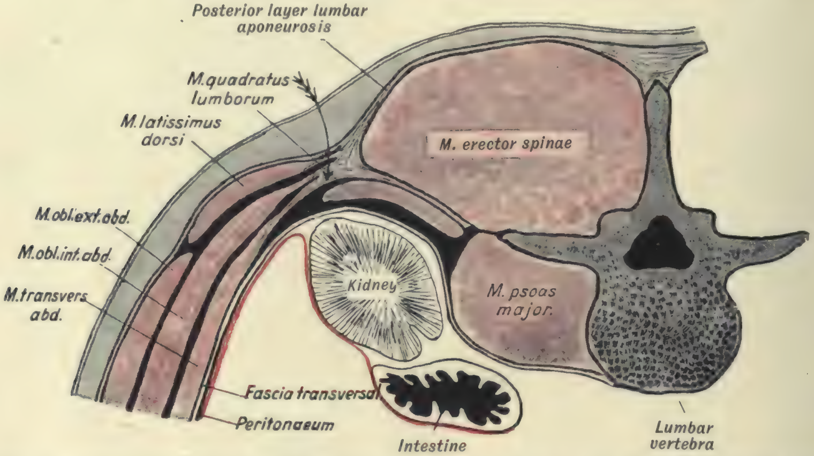

FIG. 407.—Diagrammatic cross section through the lumbar region at the level of the second lumbar vertebra (after Sobotta). The arrow indicates the path of operation, between the muscles and on to the kidney (retroperitoneal method).

The following description is based on the practice of Bier's clinic and is easy to recapitulate on the subject. Place the subject on the sound side with a sandbag under the loin ; this widens the gap between the infracostal margin and the crest of the ilium. Commence the incision at the point where the twelfth rib crosses the outer edge of the erector spinae and carry it downwards and forwards about as far as the mid axillary line : it should run about two finger-breadths below the infracostal margin. Divide the skin, the lumbar aponeurosis and the lowest fibres of the latissimus dorsi muscle, and expose the outer edge of the erector spinae. Deepen the cut outwards in the direction of the incision and divide the oblique and transversalis muscles ; next incise the fascia transversalis, taking care not to wound the peritoneum. The ilio-hypogastric nerve is found slanting obliquely over the quadratus lumborum muscle; it should be pushed inwards and retracted backwards along with the divided muscles. Then introduce the two forefingers into the perirenal fat, and it is usually possible to tear an opening through it parallel to the edge of the quadratus lumborum muscle; the kidneys are then palpable. The anterior part of the fatty capsule is drawn well forwards along with the peritoneal reflection; the latter is neither

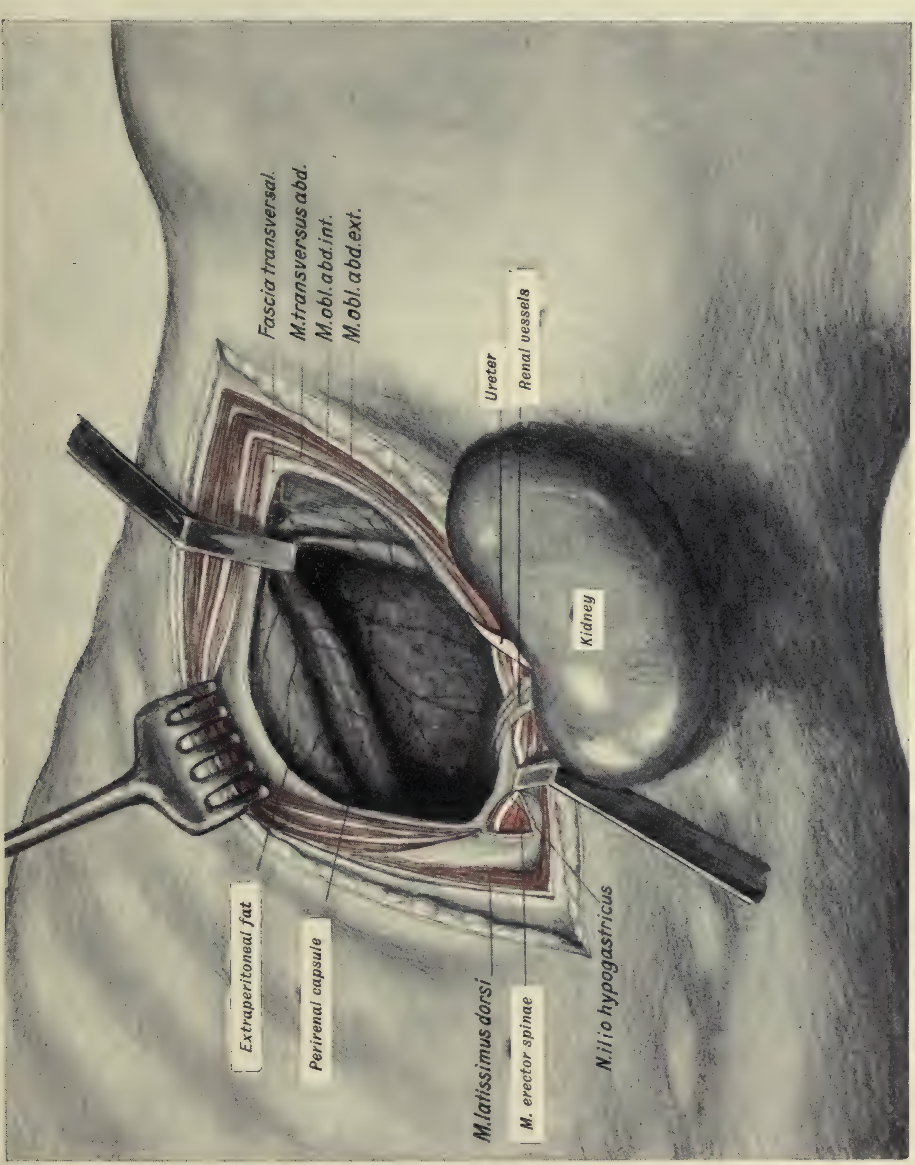

Fig. 408.—Exposure of the right kidney with the body in the left decubitus: oblique lumbar incision.

opened nor exposed, but is retracted forwards with a blunt hook; the peritoneal sac remains unopened right through the operation. The surgeon next passes his hand into the wound and frees the kidney from its fatty capsule (which is left in situ) and endeavours to hook out the organ with the fingers. This part of the operation is facilitated by an assistant clenching his fist and pressing the kidney out from the abdomen. As the kidney is being extracted the last remains of the renal fat should be stripped off the hilus; the pelvis, ureter and renal vessels are now exposed. This completes the operation for the exposure of the kidneys; it is illustrated in Fig. 408.

We then carry out the operation on the kidney, or on the pelvis and ureter, as the case may be. The wound is large and complicated and must now be attended to. It falls to be noted that if the divided oblique musculature and fasciae are not united there is a distinct tendency for lumbar rupture to occur; and if rupture does ensue operative interference will be just as necessary as in herniae of the anterior belly wall. Accordingly the various layers must be carefully sutured in the reverse order; the iliohypogastric nerve must not on any account be included in this stitch, or else chronic neuralgia will be apt to follow. Partial drainage should never be neglected unless the kidney is found to be normal on examination; even then drainage is desirable when the renal tissue has been injured or the hæmorrhage cannot be completely arrested. The cavity that remains after the extirpation of a kidney always requires temporary drainage and a tampon; the same after-treatment is called for in every excision of the kidney. If sepsis is present the wound should be kept open with a Mikulicz purse tampon. It is only the anterior part of the incision that is stitched up in these cases. The gauzes and drainage tubes are brought out at the posterior angle of the wound near the edge of the erector spinae.

In fat people or in those whose growth has been impeded, there may be considerable difficulty in freeing and luxating the kidney, more especially when it is enlarged or adherent or embedded in hard connective tissue. In such cases we may have the utmost difficulty in isolating and exposing the hilus of the kidney. The following directions will be found useful. The incision can be enlarged as far forwards as you like, in extreme cases as far as the rectus abdominis; the peritoneum may be divided at the same time. A temporary opening of the peritoneum will often come in useful in large tumours of the kidney; sometimes it is done for no other reason than to palpate the other kidney. (Practise this palpation on the subject.) The peritoneal cavity should be closed up as soon as possible; unintentional injuries should be stitched at once. The incision can be enlarged backwards by pulling in the edges of the quadratus lumborum and erector spinae muscles;

in an upward direction it is possible to obtain a splendid view by resecting the twelfth rib: a careful subperiosteal resection is necessary, for the pleural cavity may extend down as far as the twelfth rib.[1] Sometimes in spite of all these directions the kidney is so large that it cannot be extracted; if it is solid renal tissue that we are dealing with, the kidney may be extirpated in fragments (morcellement). Large cystic swellings or hydronephroses are first aspirated by Potain's apparatus and converted into empty sacs; it is then quite easy to extract them through a small opening in the parietes.

The exposure of the upper part of the ureter can be carried out by means of the above oblique incision, but if it is desired to follow it still further downwards, you avail yourself of Israel's incision, which enlarges the oblique incision in a downward direction; it diverges from the infracostal margin in the mid axillary line, and ends immediately above the anterior superior spine; it may be prolonged forwards parallel to and above Poupart's ligament. A complete survey of the ureter is now obtained; any stones lying in it can then be pushed back into the renal pelvis or extracted by opening the ureter itself.

Total extirpation of a diseased ureter may be necessary in consequence of tuberculosis or following upon nephrectomy, and the above incision enables one to do it.

The incision for the retroperitoneal exposure of the ureter is shown in the adjoining diagram (Fig. 409); the treatment of the wound at the end of the operation is the same as in the oblique incision for the kidney (*i.e.* careful suture of the various layers and gauze packing).

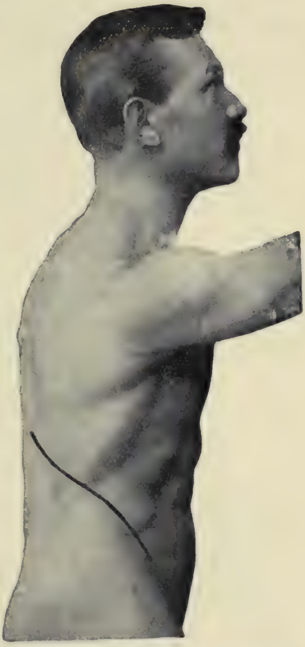

FIG. 409.—Israel's incision for the retroperitoneal exposure of the ureter.

2. *Nephrotomy and Nephrolithotomy.*

The operation begins with the usual oblique incision and the luxation of the kidney into the wound. After this is effected the exterior of the kidney should be inspected and palpated for foci of disease, and for stones in the renal pelvis or calices. A fine straight needle may be employed for locating the stones; it is thrust in at the likely spots. A clear idea as to the state of the renal parenchyma and pelvis is only obtained on sectioning the kidney; divide it in its greatest diameter, splitting it into anterior and posterior halves. Zondeck's researches on the vascular supply of the kidney have shown that there exists a line of avascularity between the anterior and posterior blood vessels; the surgeon should incise $\frac{1}{4}$ in. ($\frac{1}{2}$–1 cm.) behind the anatomical mid-line, so that the posterior portion is smaller than the anterior.

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[1] The line of pleural reflection falls below the twelfth rib at the back, between the rib and the twelfth dorsal vertebra. The operator should keep below the transverse process of the first lumbar vertebra and the ligamentum arcuatum externum.—TR.

The kidney should only be incised (nephrotomy) after devascularisation; otherwise the bleeding will be excessive and the view obscured. Formerly a thin elastic bandage was drawn round the renal vessels, but nowadays they are compressed by a rubber-guarded clamp (Fig. 410); do not clamp the ureter, however, but separate it and the renal pelvis from the vessels. The incision should extend right into the pelvis. The parenchyma can now be inspected, or a piece may even be removed for examination; or the stones may be extracted from the renal pelvis and the pelvis irrigated; one should never omit to pass a sound into the ureter.

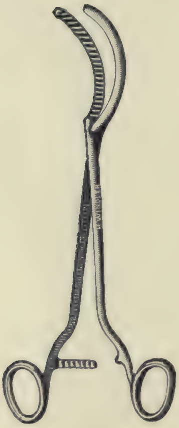


FIG. 410.—Clamp for the hilus of the kidney.

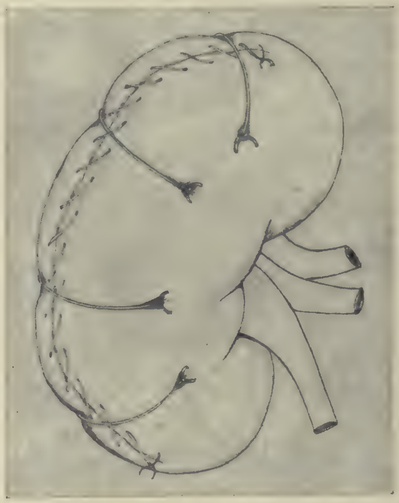


FIG. 411.—Suture ot the divided kidney. (Large button sutures, fine continuous capsular stitch.)

If the kidney is retained it should be stitched up. Three or four stout catgut sutures are passed through the kidney substance on large round needles: this brings the cut surfaces together and stops the bleeding; a fine continuous stitch is then run through the capsule and outer cortex in order to coapt the edges (*v.* Fig. 411). As in every parenchymatous stitch the threads are tied slowly and gently, so as not to cut into the renal tissue. The clamp is then taken off and a compress applied for a few minutes till the hyperaemia subsides. In infected cases the pelvis can be drained in one or more places between the stitches and the external wound is left open.

If the stones are single and easily localizable, a short incision is all that is required for nephrotomy; then introduce the palpating finger, open up the wound with blunt retractors and extract the stone with forceps. A small incision is stitched in the same way as a large one; ruptured kidneys are sutured on the same principles, *i.e.* if it is deemed desirable to retain the kidney.

Pyelolithotomy (the opening of the pelvis for the extraction of stone) has been abandoned by some surgeons in favour of nephrolithotomy, as urinary fistula was a frequent result. Pyelolithotomy is reserved for cases where there has been a spontaneous perforation of a stone through the wall of the pelvis. The danger of urinary fistula should also be remembered in performing nephrotomy, and the surgeon must see that his knife does not penetrate so far as to cut or thrust its way through the pelvis. When we are dealing with sepsis or with hydronephrotic kidneys unsuitable for extirpation it may be desirable to drop the kidney back unstitched; but it should first be swabbed out or have its cut edges stitched all round to the outer skin.

3. *Nephrectomy.*

The kidney is exposed by the usual oblique incision; diagnostic nephrotomy may also be done. If the organ is already condemned we proceed forthwith to the treatment of the renal stalk. Stout sutures are passed on aneurism needles round both artery and vein, and knotted securely as far in as possible. The vessels are divided with the scissors in such a way that they are left with the stumps long: this is to prevent the ligatures slipping off. Then seize each vessel separately with pressure forceps and surround each with a second ligature. We do not leave the renal stalk till every trace of bleeding has been stopped. If the renal vessels are short or embedded in scar tissue we may experience the greatest difficulty in carrying out the proper treatment; the vessels should then be clamped first of all and should not be ligatured till after the kidney has been excised. To guard against the danger of the clamps slipping, a small piece of the kidney may be retained for a time or even for good.

After the renal vessels have been carefully ligatured the kidney remains attached by means of the ureter alone: the latter should be drawn up a little way into the wound or followed downwards by means of Israel's incision (Fig. 409). The ureter should not on any account be torn out but must be securely ligatured and divided. We disapprove of stitching the ureter into the wound. If the ureter is diseased it is well to extirpate it.

Resection of the kidney, *i.e.* the excision of a diseased portion has been generally abandoned ; it is indicated only in the rarest of instances. Partial excisions are sutured as in nephrotomy. If we have to remove one or other pole, or if a pole has been torn off by injury, bleeding can be stopped by means of mattress sutures.

4. *Nephropexy.*

Simon's linear incision at the edge of the erector spinae is quite satisfactory. The operation may be considered in two stages : (1) the replacement of the organ in its normal position ; (2) its fixation. Retract apart the edges of the linear incision, expose the convexity and posterior surface of the kidney and get an assistant to keep it exposed.

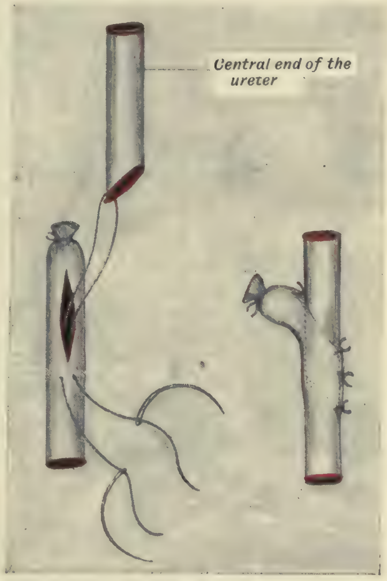
There is an infinite variety of fixation methods, a sure sign of want of success. The governing principles of operation are that neither fat nor effusion of blood should intervene between kidney and posterior abdominal wall and interfere with healing, and that the scar tissue formed between kidney and belly wall should be as thick as possible. It is best to excise the part of the fatty capsule that appears in the wound. Introduce a stout silk suture at the middle of the renal convexity and carry it transversely through the substance of the kidney ; mount both ends of the suture on strong needles and pass them from within outwards over the twelfth rib ; bring them out through the skin at different points and tie them over a roll of gauze. The only part of the kidney now seen is the lower pole ; it should be stitched with several parenchymatous catgut sutures immediately below the twelfth rib. Insert a gauze drain and stitch up the various layers of the wound.

Obalinski's method is also a good one ; he condemns complete primary suture of the wound and aims at establishing firm union between the kidney and the skin by means of packing The kidney is exposed by a linear incision and returned to its true position. The capsule is incised at its lower and posterior aspect and turned out in the form of two flaps ; these are then stitched with a few sutures to the skin on each side of the upper angle of the wound. A part of the kidney substance is thus made to present into the wound, and heals firmly to the cutaneous scar after repeated packing. The lower part of the linear incision is sutured.

These two methods make an excellent combination, their effectiveness being thereby increased.

5. *Ureteral Surgery.*

Various other operations remain to be considered in addition to simple ligature of the ureter (described in connection with nephrectomy). Uretero-plasty is concerned with the correction of abnormalities and obstructions in the ureter, usually at its junction with the renal pelvis. Ureterolithotomy means the linear opening of the ureter, extraction of the stones, probing upwards and downwards and restitching with finest catgut; this brings the edges of the wound into direct apposition. (Free drainage is essential in the after treatment.) Another knotty problem is how we are to suture a ureter that has been inadvertently severed during operation; circular suture is too insecure; various alternatives are open, *e.g.* invagination of the central end into the peripheral end, end-to-side anastomosis, or side-to-side anastomosis. The end-to-side anastomosis and invagination may be taken as the type of the methods of suture. Fine catgut is exclusively used for suturing the ureter, because silk might eventually find its way into the urinary tract and lead to incrustation and the formation of stones. The method is illustrated in Figs. 412 and 413. Ligature and shut off the distal end; a little further down cut a linear opening some $\frac{3}{8}$ in. (1 cm.) in length in the ureter. A fine suture is passed through the central end, which should be cut obliquely; each end of the thread is armed with needles and passed through the wall of the distal end; the upper end of the ureter is then drawn into the lower and stitched as in the figure with a few external sutures. This suture should not be exposed to any degree of tension. Attempts were formerly made to lessen tension by introducing a few relaxation sutures into the peri-ureteral tissues; we now realize that these stitches are conducive rather to kinking than to healing and interfere with the normal peristalsis of the ureter.



FIGS. 412 and 413.—Invagination method of reuniting a divided ureter.

The ureter becomes once more the subject of operation when it has to be implanted into some hollow viscus. The troublesome condition of urinary fistula is apt to ensue when the ureter has been injured in operating on the female genitalia or in removing a rectal carcinoma; it has then to be implanted into the bladder, and this can be effected either by the intra- or extraperitoneal methods. It is equally necessary in total extirpations of the bladder to implant the ureter into the rectum. The technique in all these cases resembles Witzel's oblique fistula into the stomach. Through a small opening the ureter is sunk into the bladder or rectum by the same method of suture as in end-to-side anastomosis of the divided ureter; a double fold of bladder or rectal wall is then drawn over the place of entrance and the ureter itself for a distance of $\frac{4}{5}$ in. (2 cm.); the stitches are introduced like Lembert's intestinal sutures. The requisite technique can easily be practised on the subject, if we only exercise care and use a fine needle. Success was not attained until surgeons began to recognize that they had attempted far too much. As already mentioned, the anchoring of the ureter by relaxation sutures has been abandoned, and the same applies to the introduction of a temporary catheter. Numerous sutures are also a mistake, as the tissues are injured by too much handling with the forceps and numerous stitches merely retard the circulation of the blood.[1]

B. Operations on the Bladder, Prostate and Urethra

Anatomical considerations.

There are a great number of indications for operating on the urinary bladder; but in the dead subject practically the only thing we can do is to expose and open it. The accompanying diagram (Fig. 414) shows how the bladder is accessible, either from above the symphysis, or from below by way of the urethra or rectum.

Fig. 414 represents a sagittal section through the male pelvis. The bladder (and associated prostate) intervenes between the symphysis and the rectum and has its upper surface covered with peritoneum. The peritoneum on leaving the bladder is folded a little way into the space of Retzius and thence is reflected on to the anterior abdominal wall. The space of Retzius is not truly a space, but is filled with loose connective tissue, fat and blood vessels; its form is very variable and depends on the distention of the bladder. If the latter is full and elevated above the level of the symphysis the peritoneal fold is also raised and it is then easy to make an extraperitoneal exposure of a large part of the anterior bladder wall (between symphysis and peritoneum). In suprapubic exposure of the bladder the surgeon can avail himself of the mobility of the anterior peritoneal reflection by operating on a full bladder. The summit of the bladder does not concern us in operations on the subject; in operative practice it may have to be stitched after intraperitoneal ruptures of the bladder. Between the bladder and the rectum the peritoneum is reflected downwards and backwards into the recto-vesical fossa; it does not invest the postero-inferior aspect of the bladder; it therefore fails to cover the prostate, seminal vesicles and orifices of the ureters.

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[1] Another method is to introduce a catheter into the bladder, make a small opening in the bladder wall, pass the catheter through, tie a suture first to the ureter and then to the eye of the catheter, retract the catheter and draw the ureter through the opening into the bladder and finally stitch the bladder wall round the implanted ureter.—Tr.

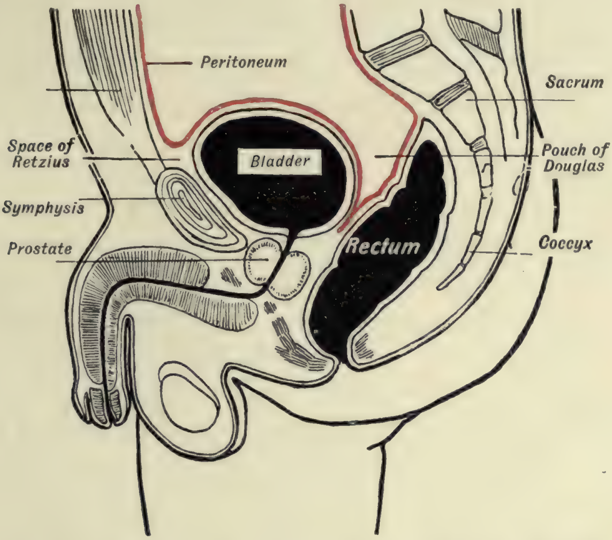


FIG. 414.—Diagrammatic sagittal section through the male pelvis.

Nowadays it is usual to operate through the space of Retzius in order to reach the interior of the bladder, but in pre-antiseptic times it was considered less dangerous to operate per rectum or through the prostatic urethra. In exposing the prostate, *e.g.* with a view to excising it, the surgeon can perform the two methods simultaneously, the suprapubic and the perineal. The perineal incision should always be practised, in order to reach the pars membranacea of the urethra (external urethrotomy).

1. *Bladder Puncture and Urinary Fistula.*

The bladder will sometimes require to be emptied in complete strictures of the urethra, and the way to puncture it is with a syringe or trocar. The suprapubic route is chosen; the idea being to thrust the instrument backwards into the bladder: it enters immediately above the symphysis, misses the peritoneum and passes through the space of Retzius. (In actual practice the bladder is quite full enough already, but in the dead subject we must fill it prior to operation. Pass a catheter through the urethra and inject some 17 to 18 ozs. of water (500 c.cm.) into the bladder. In order to prevent the escape of the water the catheter is retained and the penis surrounded with a stout ligature. If you wish to do an extraperitoneal puncture of the bladder through the space of Retzius in the living subject, first of all pass a catheter and fill the bladder: this serves to raise the line of peritoneal reflection.) The syringe is armed with a long needle; direct it immediately above the symphysis, exactly in the mid-line and at right angles to the body axis, and with one thrust send it through the soft tissues into the bladder. It is easy to appreciate the feeling of having entered the viscus.

If the trocar is used for puncturing, the technique is identical; but a small incision should first be made in the skin, or it will catch on the edge of the trocar and prevent it entering. The way to hold the trocar is illustrated in the chapter on the puncture of joints (Fig. 155). The handle is grasped firmly in the palm, while the index finger prevents the point from penetrating too far.

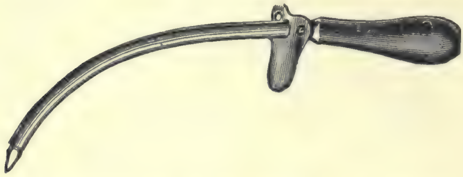


FIG. 415.—Trocar for the oblique fistula into the bladder (after Witzel).

Puncture of the bladder is quite easy; it comes in useful in emergency cases.

In impermeable strictures at the exit from the bladder it may be necessary to establish a urinary fistula. To give the patient a certain degree of control, the surgeon should imitate Witzel's oblique fistula; the technique is as follows:—Fill the bladder as in the suprapubic operation. Then take an extra long and slightly curved trocar (cp. Fig. 415), and after making a small skin incision, thrust it in at one side of the mid-line; not immediately above the symphysis, however, but a hands-breadth above it through the left rectus; force the trocar obliquely through the abdominal wall, so that its point may enter the space of Retzius above the middle of the symphysis. The handle is then lifted at right angles to the abdominal wall and the point thrust downwards into the distended bladder. On the removal of the stilette the urine flows out of the trocar. Pass a Nelaton catheter through the tube into the bladder and remove the tube over the catheter; the latter thus comes to lie in an oblique canal.

2. *Suprapubic Cystotomy* (*Epicystotomy*).

Suprapubic cystotomy is easy to practise on the subject, and is an operation of great importance; it is the preliminary to every kind of intravesical operation.

The subject lies on the back and the bladder is filled as for a suprapubic puncture. The operator stands on the left side of the body, with an assistant opposite. He palpates the symphysis and ascertains exactly the mid-line between the root of the penis and the umbo. Starting from the symphysis carry an incision some $2\frac{1}{2}$ to 3 in. (6 to 8 cm.) upwards, or even higher in people with thick abdominal walls; divide skin and subcutaneous fat and expose the anterior sheath of the rectus. Divide this sheath in the length of the skin incision exactly in the mid-line of the body, and expose the median line separating the pyramidales and recti muscles; open through it by blunt dissection and retract the muscles firmly to right and left. Next divide the very delicate fascia transversalis and come upon the prevesical layer of fatty tissues. It is in this prevesical fat that the line of peritoneal reflection lies hidden; this is not to be opened, it is not even to be exposed, but it should be displaced upwards; it is only in very spare subjects that the peritoneum is seen lying as a thin sheet in front of the bladder with the intestine sometimes shining through it. We next proceed as follows: Feel whether the abdominal incision extends right down to near the symphysis, introduce the forefinger into the fat immediately above the symphysis and draw it slowly upwards into the upper angle of the wound; substitute a blunt retractor in place of the forefinger and lift the fat and the peritoneal reflection well upwards. This exposes the extraperitoneal part of the anterior bladder wall in the space of Retzius. The bladder wall is recognized by its delicate reddish tint, by the coarseness of its muscle bundles and by the rich vascular network (mostly veins) on its surface. These veins take for the most part a longitudinal course, though not exclusively so. The student should experience no difficulty in detecting the wall of the bladder, if he only realizes that the anterior surface of the viscus is not smooth like the intraperitoneal portion; the loose areolar tissue in the space of Retzius is fused to the bladder wall itself. Before incising the bladder one should fix it with two strong sutures and draw it up into the wound; Fig. 416 shows two stout silk sutures introduced $\frac{4}{5}$ in. (2 cm.) apart; note also how the muscles are retracted by the two sharp hooks and the peritoneum drawn up with a blunt one.

The bladder is now opened by making a short linear stab incision between the two stay sutures; the urine pours out immediately and must be swabbed up at once with gauze. (In life it should be tapped, to prevent infection of the wound: an even cleaner way is to fill the bladder with oxygen.) The bladder incision is then enlarged upwards and downwards, every care being taken to shield the peritoneum from injury. Forceps are then applied to the mucous membrane of the bladder and the

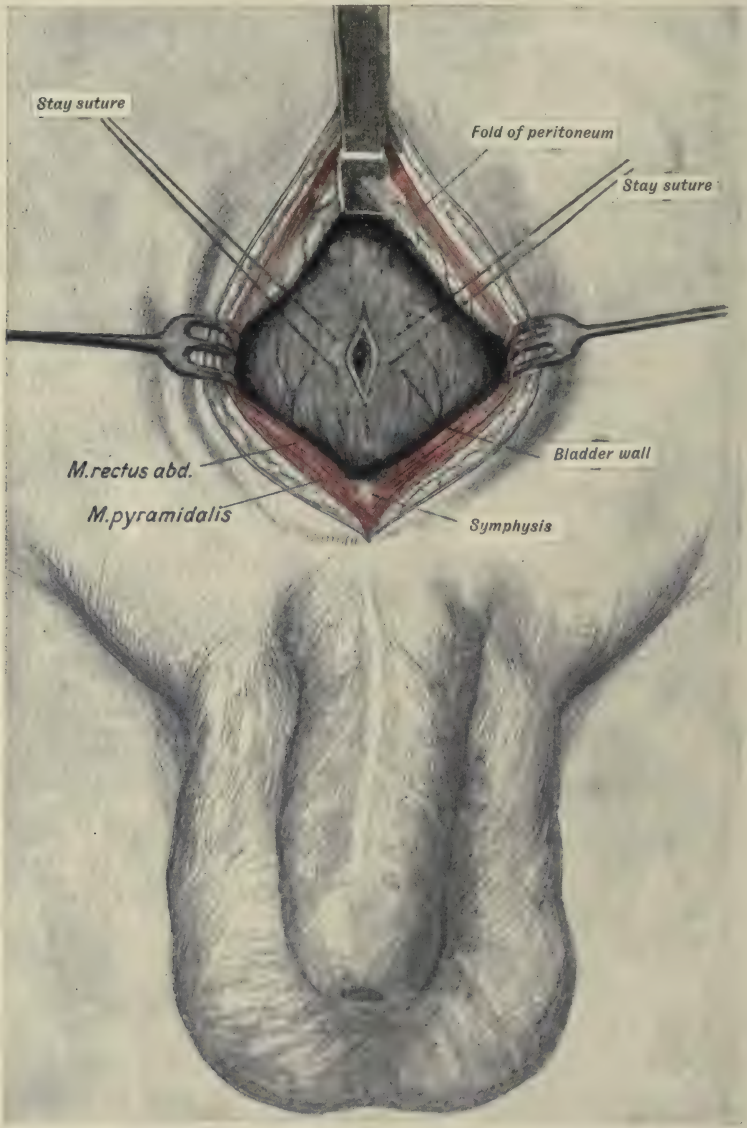
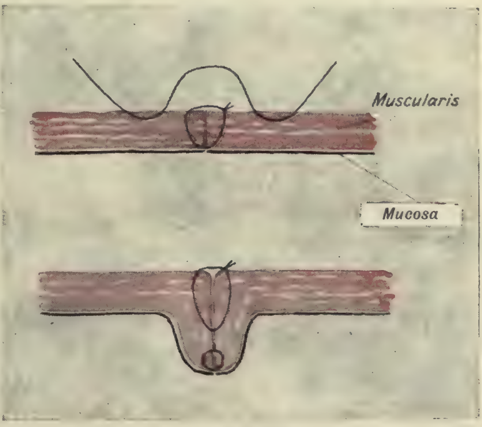


FIG. 416.—Suprapubic cystotomy. The bladder is first exposed in its extraperitoneal part by means of a linear incision: it is then opened between two stay sutures.

edges of the wound held open. The interior of the viscus is carefully swabbed out and inspected. The internal urethral orifice and the point of the catheter are visible at the base of the bladder. The catheter is then withdrawn, and an assistant introduces his finger into the rectum and pushes up the base of the bladder; on retracting the edges of the wound, the whole of the mucous membrane of the bladder and the orifices of the ureters are brought into view.

This method of operation holds good in the majority of instances. We do not consider it necessary to include a special description of the cutaneo-muscular transverse incision: many surgeons regard it as the normal method, but it seems to us to be unduly destructive. It is quite easy to enlarge the linear incision to any width desirable by nicking the insertions of the pyramidales and recti muscles immediately above the symphysis on either side (*v.* Fig. 416). Another point for consideration is whether it is not better to place the bladder incision transversely. This procedure affords easier access and facilitates the subsequent suture of the bladder; but more blood vessels are divided than in the linear incision. In transverse incisions the stay sutures should lie not vertical but horizontal.

The wound in the bladder enables us now to carry out a typical extra-peritoneal suture of the bladder. The conditions are unfavourable for healing; there is no smooth and rapidly gluing peritoneal surface. The only comparison with the Lembert suture lies in the method of stitching. The bladder is sutured in two stages, as shown in Figs. 417 and 418; care is taken not to penetrate the mucous membrane. Fine catgut is the best material for the first row of sutures; they coapt the cut edges of the bladder wall, and, as they pass through the submucous layer, they are especially useful for approximating the edges of the mucous membrane. The needle should catch up very little tissue on either side. The first row of stitches should be invaginated as in Lembert's intestinal suture. For this it is well to employ fine silk. It is best not to use it for the deeper layer of stitches, for if silk enters the bladder it is apt to lead to incrustation and formation



FIGS. 417 and 418.—Suture of the bladder in two stages.

of stone. In isolated instances a rubber tube should be introduced into the bladder at the upper angle of the wound and stitched in place. It is the general practice to leave part of the abdominal incision open and to leave a drain or tampon in the space of Retzius, for if the bladder stitches yield there is grave risk of urinary infiltration.

3. *Catheterisation.*

By catheterisation is meant the artificial emptying of the urinary bladder by means of a tube passed through the urethra. This procedure is quite easy in the short straight urethra of the female; all that is needed is to open up the labia majora and minora and introduce a short tube (Fig. 420) through the urethral opening, which is visible at the anterior wall of the vagina. The passage of the catheter through the male urethra is a much more difficult business. The introduction of the metal catheter (Fig. 419) may be learnt on the dead subject; the catheter is a smooth tube open at one end and bent at the other, where it has two lateral eyelets.

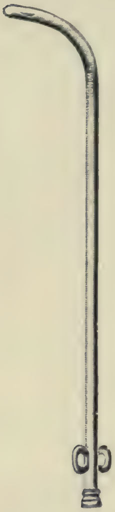


FIG. 419.—Male catheter.

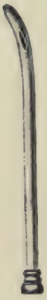


FIG. 420.—Female catheter.

The male urethra is much longer than that of the female; it corresponds to the shape of the catheter (1) when the penis is erect; (2) when the body is lying in the dorsal decubitus and the penis is lifted upwards and its curves straightened out. When the penis is flaccid the urethra assumes a double S-shaped curve (cp. Fig 414). The urethra leaves the bladder at the internal urethral orifice; it descends first through the prostate (prostatic portion), is continued downwards as the membranous portion, and then curves forwards and runs under the symphysis as the long cavernous portion, which is surrounded by the corpus cavernosum urethrae. In the relaxed state of the penis the canal takes a second bend downwards on reaching the front of the symphysis and is continued into the most movable part of the cavernous (sometimes termed the pendulous portion). On straightening out the sharp curve in front of the symphysis we alter the S shape of the urethra and make it assume the form of the catheter. The posterior curve cannot be altered ; the parts above the pelvic diaphragm (pars membranacea and pars prostatica) are therefore sometimes called the fixed portion. The width of the lumen varies in the different parts of the canal. The narrowest part is at the external orifice at the tip of the glans ; sometimes before a thick catheter can be introduced we are obliged to snip the meatus with the scissors ; immediately behind this the urethra widens out for a short distance to form the fossa navicularis ; still further backwards we come to another dilatation opposite the bulb in the posterior part of the cavernous portion ; the urethra narrows again in the membranous portion, and this point of narrowing is called the isthmus urethrae. It is this passage from the wide bulbous to the narrow membranous portion that offers the chief obstacle to successful catheterisation. It is here at the triangular ligament that the catheter tends to be arrested.

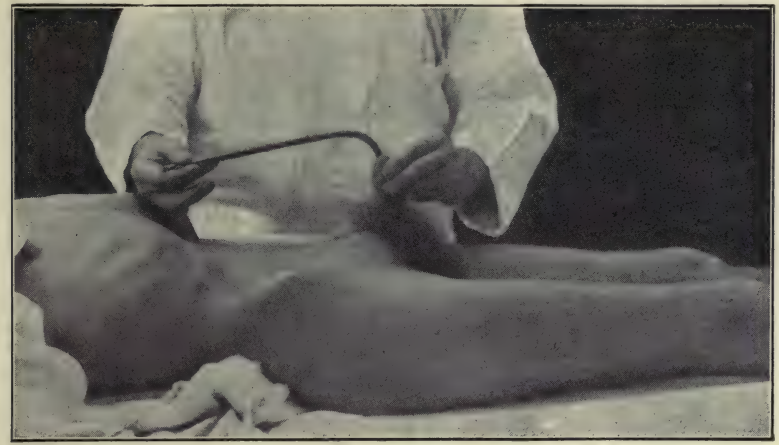


FIG. 421.—Passage of the catheter. I. Stage. Take the glans in the left hand and rest the right on the abdomen near the umbilicus : introduce the end of the catheter into the external urethral orifice.

We must avoid the use of force in the passage of the catheter ; even the skilled surgeon feels it no disgrace if he spends some time in manipulation, or occasionally withdraws the catheter a little ; the chief danger lies in lacerating or perforating the posterior wall of the urethra at the point where narrowing occurs ; hæmorrhages and false passages will then be sure to result. The surgeon should have a feeling as if the catheter were finding its own way in. He should start with a fairly big catheter and should not allow it to deviate from the mid-line. Standing on the left side of the body (which lies on the dorsum) he grasps the glans penis with the finger and thumb of the left hand, retracts the foreskin and gently pulls back and everts the lips of the external urethral orifice (*v.* Fig. 421) ; his right hand rests on the abdominal wall near the umbilicus. Seizing the handle of the catheter (which should be well oiled) he pulls the penis towards the umbo and draws it over the bend and up to the middle of the instrument. Keeping the penis extended upwards he slides the tip of the catheter over the symphysis and into the bulbous urethra, where it lies at no great depth and can be palpated through the skin of the perineum (Fig. 422). The right hand is only now raised from the abdomen ; the handle of the instrument is lifted carefully and without the use of any force ; the penis is kept on the

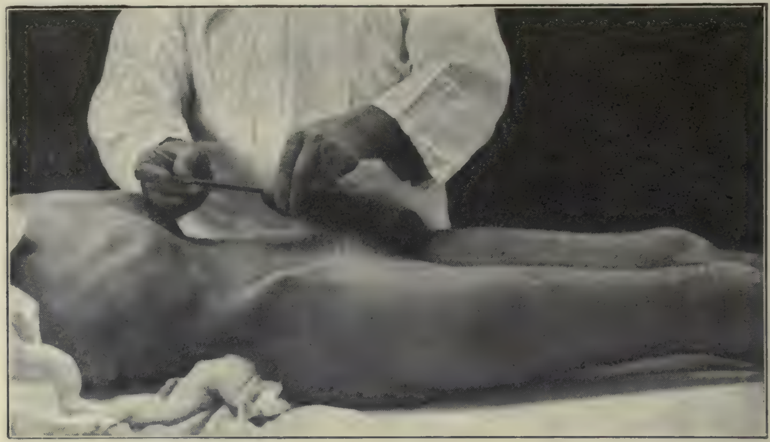


FIG. 422.—Passage of the catheter. II. Stage. Push the penis along the catheter, keeping the latter in the same position as in Stage I., until the bill of the catheter glides downwards over the symphysis.

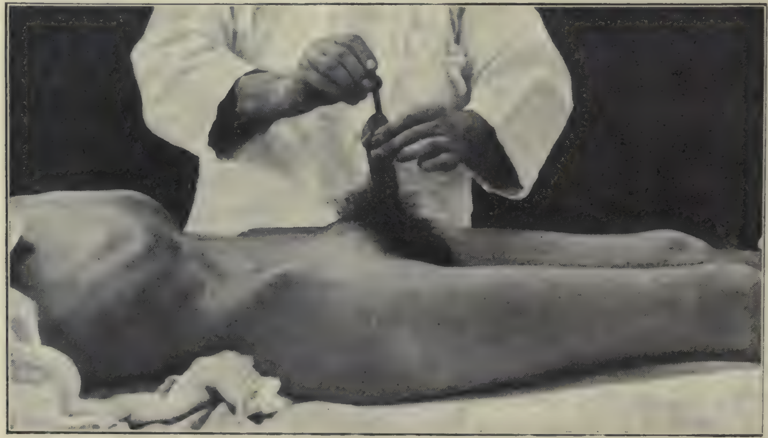


FIG. 423.—Passage of the catheter. III. Stage. Slowly raise the right hand, keeping the penis on the stretch ; the catheter glides round the symphysis and reaches the posterior part of the urethra.

stretch. In this way the catheter usually slides easily over the danger zone; if any obstacle be encountered, do not press onward but withdraw the catheter a little and try again. It is only after repeated failures that recourse is had to a smaller instrument (Fig. 423). On surmounting the obstacle the catheter is depressed between the thighs and pushed onwards. This should also be done without force: the best way is to tilt the catheter with one finger (Fig. 424). An outflow of urine denotes that the catheterisation has been successful. (It is little use to practise catheterisation unless the subject is a fresh one.)

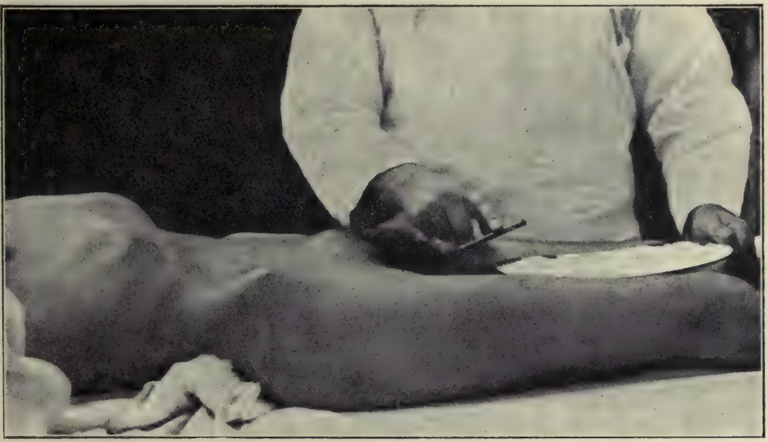


FIG. 424.—Passage of the catheter. IV. Stage. Take away the left hand, depress the right hand, using no force (the finger alone should suffice), and push the instrument on into the bladder.

4. *External Urethrotomy* (*Median lithotomy. Sectio mediana*).

The aim of this operation is to expose the membranous part of the urethra from the perineum with a view to entering the bladder. But before attempting it the surgeon must have a grasp of the anatomical relations, for it is easy to injure the neighbouring structures; the line of advance is between the bulb of the urethra and the rectum.

Place the subject in the lithotomy position, *i.e.* bring it to the lower edge of the table and separate the legs, with the hip and knee joints strongly flexed; they should be retained in this position by two assistants. The operator sits on a chair facing the perineum. Draw the external genitalia forwards. It is best to introduce a metal catheter before placing the body in the lithotomy position. A special metal bougie, shaped like a catheter, is used in incising the urethra (staff, Fig. 425); it carries a deep groove on the convex side and it is along this that the longitudinal division of the urethra is made. An assistant holds the instrument in the urethra exactly in the mid-line of the body. It can be felt through the skin of the perineum in thin subjects. We have a choice of incision, either a linear one in the raphe between the root of the scrotum and the anus, or a curved one running round the anus and crossing the centre of the raphe. We prefer the latter, for it can be enlarged at will and it serves for every perineal operation on the urethra, seminal vesicles and prostate, and in extravasations into the soft tissues. First expose the skin and fat, then expose the bulb of the urethra, which is covered by the two accelerator urinae (bulbo-cavernosi) muscles; their fibres are oblique and they meet in the mid-line. The bulb is flanked on either side by the erectores penis (ischio-cavernosi) muscles. In exposing the bulb we divide the fibres of the superficial transversus perinei muscle, separate the fibres of the levator ani, insert a sharp retractor immediately behind the bulbus urethrae and pull it forward; in a downward direction we hold the wound open with a blunt retractor, taking care not to injure the rectum. The beginner should never neglect to introduce his finger into the rectum and satisfy himself as to its proximity. If the two retractors have been properly applied, the staff can easily be felt in the membranous portion of the urethra, which is only ½–¾ in. (1½–2 cm.) in length; the rounded outline of the urethra can be felt even without any staff or catheter; the prostate is palpable just behind this, in immediate apposition to the anterior wall of the rectum. The membranous portion is then divided on the grooved staff,[1] and the staff is withdrawn; we can now introduce an instrument or the finger into the bladder. In order to keep a hold on the urethra, two ligatures should be passed through it, or its edges should be seized with Pean's forceps. This stage of the operation is represented in Fig. 426.

FIG. 425.—Staff for median lithotomy.

5. *Prostatectomy.*

We shall not enter into the minutiae of prostatic operations; in the normal subject we cannot do more than practise the typical exposure of the gland. Enucleation is the principal surgical operation, but it cannot be practised unless the prostate is hypertrophied. There are two ways of reaching the gland, either through the bladder (suprapubic route) or from the perineum (perineal route). The preliminary operations are suprapubic cystotomy (Fig. 416), and the perineal exposure of the urethra as just described (Fig. 426). A metal catheter is passed in both instances. The first step in suprapubic prostatectomy is to open the bladder; then introduce the finger and make out the projecting end of the catheter; the prostate lies immediately behind it. The mucous membrane over the prostate is then caught up with a pair of toothed forceps and the catheter removed; an assistant introduces his forefinger into the rectum and pushes up the prostatic gland as far as possible. A curved incision is then made behind the internal urethral orifice; it divides the mucous membrane of the bladder and the capsule of the prostate. Then press the right forefinger between the capsule and the gland and enucieate it by means of blunt dissection. The

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[1] Some of the fibres of the triangular ligament are incised at this stage.—TR.

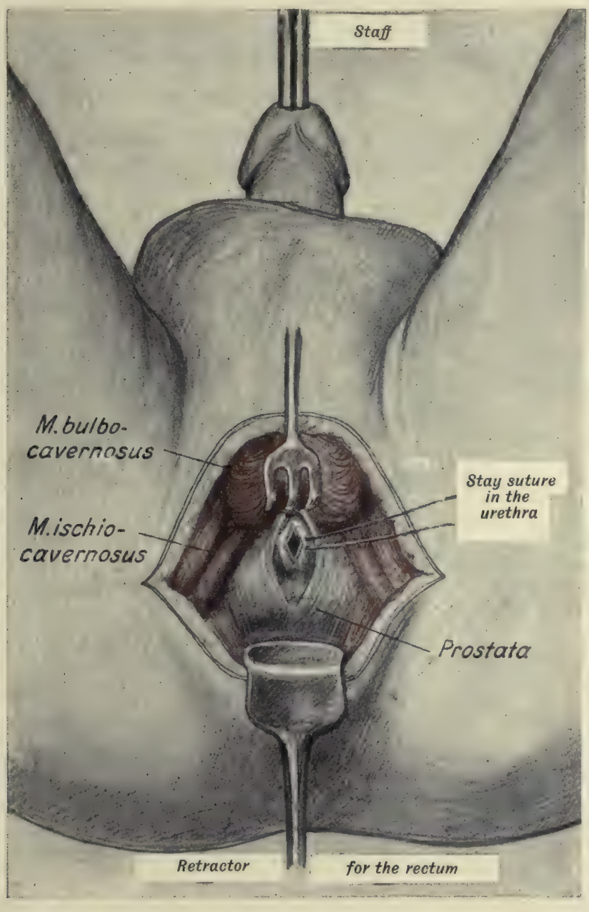


FIG. 426.—External urethrotomy (median lithotomy).

prostatic urethra will be torn to a greater or lesser degree according to the size and character of the glandular enlargement. In excessive enlargement of the lateral lobes the gland can be enucleated in two halves.

The perineal method of prostatectomy also aims at enucleating the organ out of its capsule. Place the body in the lithotomy position, and expose the membranous part of the urethra by means of the curved para-anal incision. Penetrating still deeper push the rectum downwards and free the prostate till it is possible to hook the finger over it; then enucleate the lateral lobes one after the other. First run a linear incision through the capsule on one side, introduce the forefinger and do a blunt enucleation of the lateral lobe on this side; then do the same on the other side. The urethra is opened in the majority of cases; it is as well therefore to open it by a median section before starting to enucleate. Then insert Young's retractor (Fig. 427) through the urethra and into the bladder, and use it to draw down the prostate into the perineal wound. It is an excellent method of fixing it preparatory to enucleation.

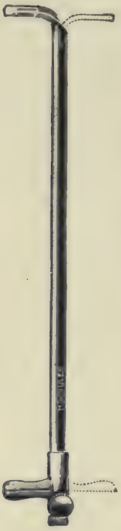


Fig. 427.—Young's retractor for perineal prostatectomy.

The after treatment in both the methods of prostatectomy is difficult and onerous; it is fully discussed in the ordinary textbooks of operative surgery. Open treatment is best; the urine can then be drained off and the after bleeding kept within limits.

C. Operations on the External Genitals

1. *Operation for Phimosis.*

Phimosis consists in a narrowing of the preputial orifice; it is cured by enlargement of the same. It is to be borne in mind that the constriction belongs essentially to the inner layer of the foreskin. There are two methods of operation.

(*a*) *Linear incision.*

The prepuce is split up the dorsum; one can either incise it on a grooved probe or introduce a pair of straight scissors (with guarded ends) under the foreskin. In introducing the probe or the blade of a scissors take care that the instrument does not find its way into the urethral orifice. When the cuticle and the inner layer of the prepuce have been slit up as far as the middle of the glans, the cuticle will be seen to have retracted more than the mucous membrane, which has usually to be incised still further or trimmed off. The cuticle is then stitched to the mucous membrane in the length of the incision (Fig. 428) ; the suture may be continuous (finest catgut) or interrupted (finest silk), and is usually effective in controlling the bleeding.

The cosmetic result of this single dorsal incision is anything but beautiful and it is often replaced by two lateral incisions ; the method of incision and the stitching are just the same.

(*b*) *Circumcision.*

Seize the prepuce with the fingers and pull it well forwards over the glans. Cut it away transversely, taking care to avoid the glans. The retraction of the outer cuticle again obliges one to trim the inner layer all round, in order to allow the outer and inner layers to be retracted easily and without tension over the corona glandis. The outer cuticle is then stitched to the inner layer of the prepuce (Fig. 429), or retracted back over the corona and stitched there.

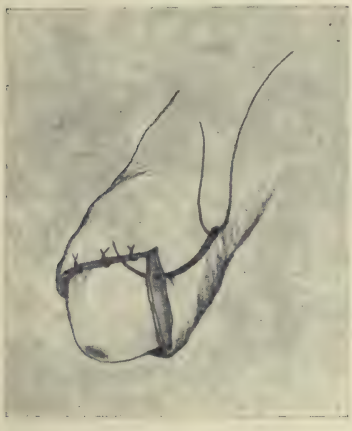


FIG. 428.—Operation for relief of phimosis (Linear cut).

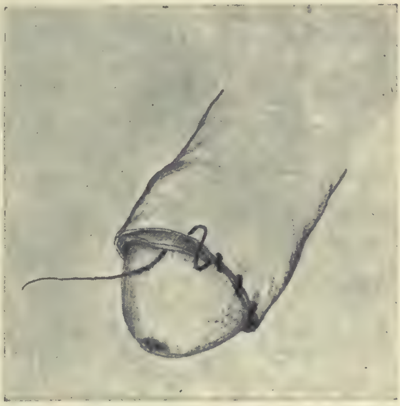
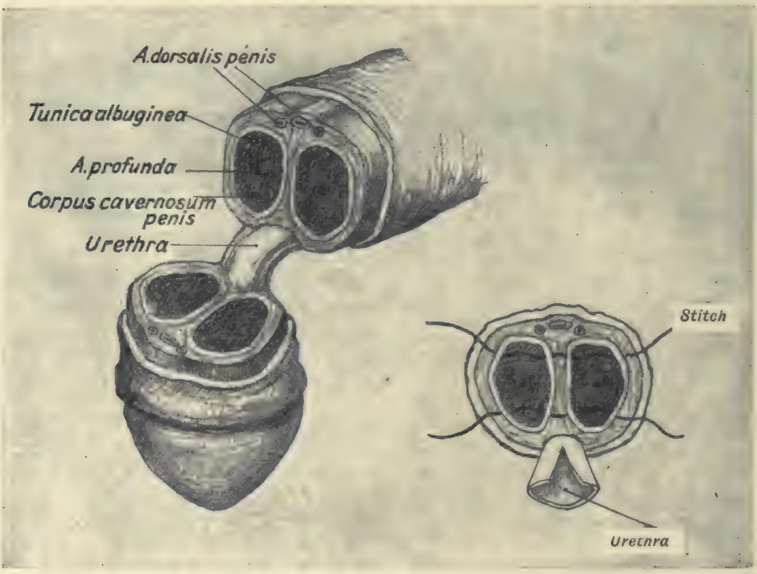


FIG. 429.—Operation for relief of phimosis (Circumcision).

The method of dorsal incision and circumcision can be advantageously combined in suitable cases. This can be done (1) when the prepuce is long and projecting and an inelegant preputial flap is left hanging after the dorsal incision ; (2) when, after circumcision, the prepuce cannot be freely retracted without the addition of a dorsal cut.

2. *Amputation of the Penis.*

(*a*) Amputation of the penis through the pendulous part (generally for carcinoma of the glans and prepuce) is a bloodless method; the skin of the penis is drawn back and the penis constricted at its root with a thin rubber band. The glans (not the prepuce) is seized with a sharp retractor and put upon the stretch. The surgeon then divides the skin and fascia of the penis, till he exposes the albuginea of the corpora cavernosa; he then makes an even transverse cut through the two corpora cavernosa from the dorsum and allows the distal end of the penis to hang by the urethra and the corpus spongiosum (*v.* Fig. 430). In operating without the elastic band one should pass sutures to prevent the corpora cavernosa slipping backwards, as they bleed very freely. Then free the urethra and corpus spongiosum from the corpora cavernosa for about 1 cm. further forward and divide the urethra there, so that it projects 1 cm. beyond the stump of amputation. This finishes the amputation. Attend now to haemostasis; apart from the ligature of a few subcutaneous veins this consists in ligaturing the two dorsalis penis arteries and securing the deep arteries of the corpora cavernosa. Oozing from the cavernous tissue itself can be controlled by the suture method shown in Fig. 431, which consists essentially in seizing and stitching together the edges of the albuginea so as to close the corpora



FIGS. 430 and 431.—Amputation of the penis: cross-section and stitching of the same.

cavernosa ; an even better way of suturing the corpora cavernosa is to pull the intervening septum pectiniforme well forwards and snip off a piece with the scissors. The projecting stump of urethra is then split up the dorsum (*v.* Fig. 431), reflected out as two flaps and stitched all round to the outer skin with silk sutures. If a piece of urethra is not left projecting, and if it is not split in this way, troublesome strictures are apt to ensue at the new external orifice. In every carcinoma of the penis the inguinal glands must be cleared out on both sides (cp. Chapter X. in Part VI.).

(*b*) If the carcinoma has invaded the corpora cavernosa, it is best to extirpate the whole penis as far as the crura. Lay the subject on the back and draw it down to the edge of the table, with the legs propped up and the hips sharply flexed (lithotomy position). Run a circular incision round the root of the penis, split up the scrotum along its raphe and retract the two halves apart ; expose the corpora cavernosa between them and free the crura from the pubic rami by dividing their ligamentous connections ; the bleeding is usually profuse. The urethra is left long and is stitched into the skin of the perineum ; a gum-elastic catheter is introduced for a time. The wound is a large one ; stitch it up in layers and provide for drainage.

3. *Treatment of Hydrocele.*

By hydrocele testis is meant a pathological collection of serous fluid in the enlarged tunica vaginalis propria of the testicle. Hydrocele of the spermatic cord is a similar affection occurring at a higher level. The radical cure of hydrocele aims at the emptying of the sac and the subsequent obliteration of its cavity. We give a short description of three methods that attain this end. The first step in all of them is to make a longitudinal incision through the skin of the scrotum and divide the coverings of the testicle layer by layer, and then to slit up and empty the hydrocele itself.

(*a*) *v. Bergmann's operation for hydrocele.*

Starting at the cut edges of the tunica vaginalis propria separate it from its coverings by blunt dissection ; then trim it off at its line of reflection to the testicle and epididymis. This stage of the operation is shown in Fig. 432. Attend carefully to the bleeding. Replace the testicle in the scrotum and stitch the skin. (Drainage is advisable, for it is difficult to secure absolute haemostasis.)

(*b*) *Winkelmann's operation for hydrocele.*

Expose the testicle in the usual way. The tunica vaginalis is neither separated nor cut away, but the two sides of the divided sac are folded behind the testicle and round the root of the spermatic cord, and fixed there with a few sutures. After the serous cavity has been obliterated in this way (cp. Fig. 433) the testicle is replaced in the scrotum and the wound in the skin is stitched up. The operation is a capital one, for the bleeding is slight and no drainage is required.

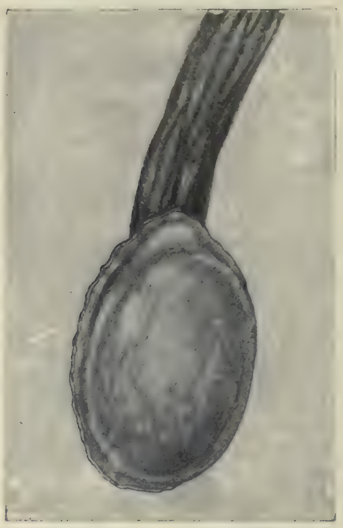


FIG. 432.—v. Bergmann's operation for hydrocele.

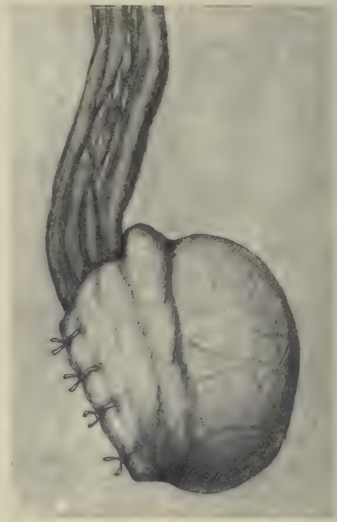


FIG. 433.—Winkelmann's operation for hydrocele.

(*c*) *Klapp's operation for hydrocele.*

The aim of this operation is the same:—obliteration of the sac of the hydrocele without the risk of after-bleeding. The sac is opened and spread out to expose the testicle. The surgeon then introduces a crown of fine radial sutures, as illustrated in Fig. 434, and folds the tunica vaginalis into a collar all round the testicle; this narrow ring will soon shrivel up. The testicle is replaced as before, and the wound closed without drainage, there being no danger of after-bleeding.

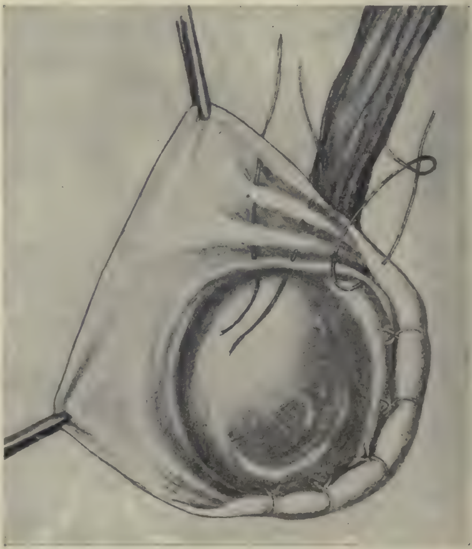


FIG. 434.—Klapp's operation for hydrocele.

4. *Excision of the Testicle* (*Castration*).

The excision of a normal testicle, as found in the ordinary subject, or the excision of a diseased but freely mobile testicle is technically an exceedingly simple operation. Seize the testicle, and with the finger and thumb of the left hand stretch the skin of the scrotum over it; divide the skin and tunica dartos by a linear incision and expose the testicle; the latter is enveloped by the tunica vaginalis communis, which (together with the fibres of the cremasteric muscle) invests the cord as well. The testicle is first freed from the scrotum; a firm connection exists between it and the skin at its lower pole, but this is all that requires to be divided. The gland is now ready for excision. But before it is removed, a diagnostic incision should be made into it, except where no dubiety exists as to the condition. The remaining tunics are divided as far as the albuginea and we inspect the testicle, epididymis and any parts affected by disease. If it is decided to excise the testicle, the vas deferens should be excised as far up the cord as possible; it can be felt as a hard cord the thickness of a quill; it is finally divided without being ligatured. All the other structures of the spermatic cord, consisting of the coverings, the spermatic artery and artery to the vas, and numerous veins and nerves (pampiniform plexus) are ligatured en masse; the surest way is to apply two ligatures a little way apart, and to divide the cord between but not too near either of them (*v.* Fig. 435). The ligatures must be reliable and tight, for they are apt to slip off (and bleeding from a stump that has slipped back may be quite an unpleasant accident). The layers of the wound are then sutured, and a small drainage tube is left for a day in the empty scrotal sac to forestall any bleeding. (Fig. 435 shows the operation previous to the division of the vas deferens; the tunica vaginalis propria of the testis has been opened for illustrative purposes.)

The operation is simple but it is frequently modified to suit the incidence of disease. Unilateral castration is very often performed on account of tuberculosis; the vas deferens must then be followed right up into the inguinal canal. Tearing out of the vas deferens has been abandoned, for it might tear away at a diseased point and infect the wound higher up with tubercule. If the tuberculosis is advanced and has overstepped the testicular coats and abscesses and fistulae have formed and soldered the testis to the skin, some of the scrotal skin should also be excised. But in these cases the operation is begun in a different way. As in inguinal herniotomy (which see) we make an oblique incision above Poupart's ligament, divide the inguinal canal and expose the spermatic cord above the level of the infection. The spermatic cord and the vas deferens can now be ligatured and divided at the internal ring as above described. It is only when the inguinal canal has been emptied and resutured in two layers with catgut that we proceed to separate and remove the lower part of the spermatic cord, the testicle and any parts of skin that are implicated by the disease. The same procedure applies to malignant tumours (once the diagnosis of malignancy has been established), for the treatment of the inguinal canal is always a more aseptic operation than the opening of the scrotal sac. In connection with this inguinal operation it is sometimes possible to excise the diseased inguinal glands.

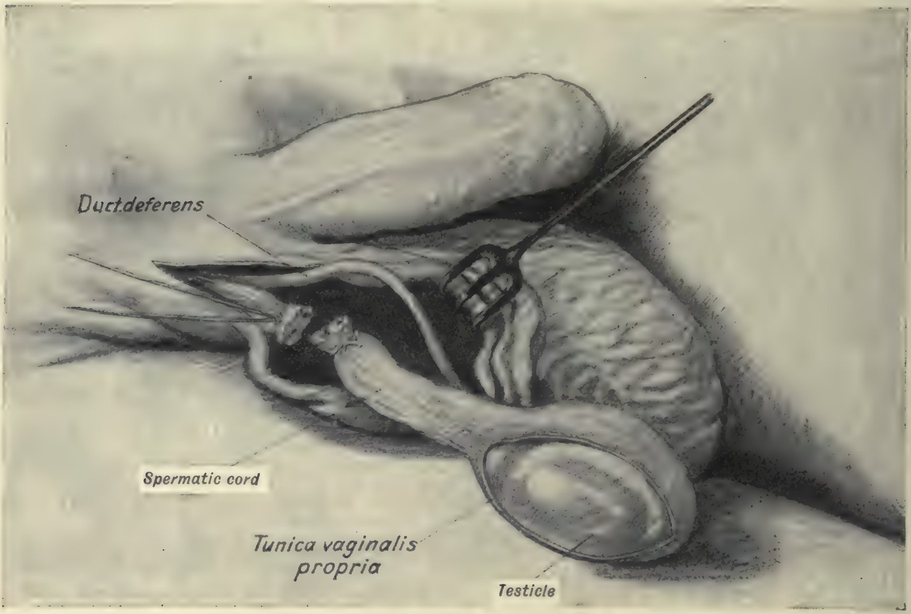


FIG. 435.—Extirpation of testicle (Castration).

The excision of the epididymis alone is only undertaken in very exceptional cases.

APPENDIX—(Tr.)

A. Lumbar Puncture

Lumbar puncture has become of great importance. Solutions of cocain or stovain (*e.g.* 1·3 cub. cm. of a 5 per cent. solution of tropococain), with or without adrenalin, are injected into the subarachnoid space in order to produce spinal analgesia. The lumbar region is chosen because the cord does not usually extend below the lower border of the first lumbar vertebra; the strands of cauda equina are liable to be injured but are of minor importance. The range of anæsthesia can be regulated by raising or lowering the shoulders of the patient.

Place the patient in the sitting posture and get him to bend well forwards; this opens up the interlaminar spaces. Draw a line between the summits of the iliac crests: this crosses the 4th lumbar spine or 4th interspace. Palpate the lumbar spines, and select the 1st, 2nd, 3rd or 4th interspace for puncture (cp. Fig. 303). Take a thin trocar and cannula and thrust it through the interspace, preferably in the mid-line, and at right angles to the vertebral column. The needle traverses skin, subcutaneous fascia, posterior layer of lumbar aponeurosis, interspinous ligaments, ligamenta subflava, spinal periosteum, internal spinal veins, dura mater and arachnoid before entering the subarachnoid space. Withdraw the trocar.

You can tell a successful puncture by the feel of the instrument as it enters the spinal cord and by the free flow of clear subarachnoid fluid; the first few drops may be blood-tinged. If nothing but blood comes away you have punctured the vessels to the erector spinae or the rich venous sinuses that lie both behind and in front of the neural arches. If no liquor issues from the cannula, the needle has either not met the fluid at all or has got blocked with some strands of the cauda.

The subarachnoid fluid should be allowed to run out and mix with the solution in the syringe; the mixture is then injected, withdrawn, and again injected. The liquor is thus brought into intimate relation with the anæsthetic.

B. Varicose Veins

Veins have thinner and weaker walls than arteries. The majority of them are therefore supplied with valves which assist the flow of blood towards the heart. A deficiency of vascular tone manifests itself by dilatation of the vessel wall, the valves become incompetent and varicosity is the result. Compensatory thickening and tortuosity occur frequently. Back pressure from any cause affects chiefly those veins which support a long column of blood, or are badly supported, or are deficient in valves. The hæmorrhoidal veins of the rectum are subject to all these conditions, and are exposed to local congestions and the stress of the portal circulation as well.

1. *Varicose Veins of the Leg* (*Varix*).

The principle of operation is to occlude the superficial veins and divert the venous blood to the deep vessels (which have the muscles to support them).

A simple method (Trendelenburg's) is to doubly ligature and divide the internal saphenous vein immediately below the saphenous opening (Figs. 11 and 264). It fails to afford relief in most cases owing to the free anastomosis between the veins, and should be reserved for those cases where there is clear evidence of regurgitation from the femoral vein into the saphenous.

If the dilated vein is long and single it is possible to carry the skin incision downwards from the saphenous opening to the knee or to the ankle, and do a complete excision. To avoid such a long skin incision C. H. Mayo employs a subcutaneous method. He exposes the vein at the saphenous opening, doubly ligatures it, threads the lower end on a dissector, passes the instrument down under the skin and brings it out near the knee. Long strips of vein can be excised in this way.

Usually, however, varicose veins are multiple rather than single and affect the calf more often than the thigh. Schede's garter incisions are then available: Apply an Esmarch's bandage, and make a circular incision round or partly round the leg, dividing all the tissues of the calf down to the deep fascia ; ligature off the pouting veins, take off the Esmarch, stanch the bleeding and stitch up the wound. Several garter incisions may be made.

Friedel's operation is a modification of Schede's method; a continuous spiral incision is carried from knee to ankle, dividing all the veins en route.

2. *Varicose Veins of the Pampiniform Plexus* (*Varicocele*).

The pampiniform plexus lies with the vas deferens posterior to the other elements of the spermatic cord.

Incise over the external abdominal ring; at this point the veins are less numerous, the cord is more easily isolated and the after-healing more rapid than when the scrotum is incised. Expose the cord and isolate it from the external ring to the testicle; isolate the veins of the plexus and encircle them with a couple of ligatures above and below, taking care not to include the vas deferens (Fig. 435); tie the ligatures tight and excise the veins between them; tie the ends of the sutures together, thus drawing up the testicle; replace the cord and suture the skin. The vas feels like a thin piece of whipcord when rolled between the finger and thumb; it is accompanied by the artery to the vas, which is capable of nourishing the testicle even when the spermatic artery has been occluded along with the veins.

3. *Varicose Veins of the Hæmorrhoidal Plexus* (*Hæmorrhoids*, *Piles*).

The two chief methods of operation are (1) by clamp and cautery; (2) by ligaturing the piles. The former runs as follows :—

Empty the lower bowel prior to operation. Dilate up the anus thoroughly with the forefingers, seize the individual piles with forceps and draw them well out. Apply the clamp to the base of each pile in turn, crush it, snip off the protruding part with the scissors (not too close to the clamp), and cauterise the base carefully at a red heat; then release the clamp and observe if hæmostasis has been complete. Do the same to the other piles. The clamp must always be applied radially to the gut (not transversely), in order to avoid the risk of after-stenosis; take care to include only the mucous membrane and none of the skin in the clamp. A strip of oiled gauze is inserted into the rectum in order to apprise us of any after-hæmorrhage.

A morphia suppository is introduced to keep the part at rest.

C. UMBILICAL HERNIA.

In addition to the inguinal and femoral varieties, umbilical hernia is also frequent. Certain of the abdominal contents may protrude through a weakening of the abdominal wall at the umbilicus. Omentum forms the commonest constituent of the sac, though the transverse colon does sometimes project. The object of the operation is to reduce the contents of the sac, and to imbricate the abdominal parietes over the opening so as to prevent recurrence. This may be effected in two ways:—

1. By the classical linear incision.
2. By the transverse incision of the Mayos.

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